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ABSTRACT

The instructional process has four major components: stimulation, orientation, transformation, and instrumental activity. Concerning stimulation, the instructor should highlight either the novelty or the complexity of the learning materials. Varying such factors as teaching style and mode of presentation, duration of instruction, and the learner's physical position will maintain or heighten attention. Concerning orientation, the best way to get a student to master the lesson is to ask questions shortly after the material has been presented. More research needs to be done on the value of the classroom assignment. Three types of transformation, from elementary to sophisticated, let the student internalize the lesson. These types of transformation allow measurement and isolation of variables which can be used according to the objectives of the materials. Although more research on the subject is needed, preliminary studies show that two types of instrumental activity--note-taking and verbalization--are helpful in fostering learning. (JK)

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Instructional Strategies:
Multivariable Studies of Psychological
Processes Related to Instruction

Francis J. Di Vesta
Nicholas M. Sanders
Charles B. Schultz
Paul D. Weener

INSTRUCTIONAL STRATEGIES: A MODEL AND ITS APPLICATION

Annual Report

July, 1971

Part I

Advanced Research Projects Agency

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TABLE OF CONTENTS

FOREWORD 1

CHAPTER ONE
A Theory of Instructional Strategy
by Francis J. Di Vesta 3

CHAPTER TWO
Cognitive Stimulation in Instructional Strategies
by Charles B. Schultz 27

CHAPTER THREE
Strategies for Orienting Students to Educational Objectives
by Nicholas M. Sanders 75

CHAPTER FOUR
Instructional Strategies and Learner Transformations
by Francis J. Di Vesta 93

CHAPTER FIVE
Student Instrumental Activities and Instructional Strategies
by Paul D. Weener 139

CHAPTER SIX
A Summary and Overview
by Nicholas M. Sanders 173

APPENDIX 179

Foreword

Rather than include an introduction to the technical reports as we have done in the past, we have prepared a separate volume which summarizes in large part our own experience with research on instructional strategies and on aptitude-treatment interactions. In the main, these summaries deal with substantive issues related to a theory of instructional strategies rather than with methodology. It is hoped that other investigators will elaborate, revise, and build upon this theory as a conceptualization of the teaching-learning process.

The first chapter in the present volume is a brief outline of a theory of instruction. The next two chapters deal with teacher-student activity supportive of learning. Chapter Two centers on the activation of the learner while Chapter Three is an examination of the effects of learner goals and expectations on learning outcomes. Chapter Four deals with transformational processes of learning together with some instructional activities that facilitate these processes. Chapter Five is concerned with the way student activities are influenced by instruction and, in turn, affect what is learned. Finally, Chapter Six is a brief integration of the elements of the theory which were detailed in the five previous chapters.

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Chapter One

A Theory of Instructional Strategy

Francis J. Di Vesta

An instructional theory can be approached from the standpoint of the learning process or of the instructional process. In either case it seems the difference is only a matter of emphasis because neither can be treated to the exclusion of the other; it would be foolhardy to make such an attempt. The eventual requirements of a theory are that it encompasses prescriptions for the instructor's activities, considerations of the student's activities as affected by instructional strategies, accommodating to individual differences, and clarification of the relationships between these factors and objectives to be achieved.

In a theory of instruction, the activities of the instructor should be ennumerated in terms that can be communicated to teachers and can be reliably translated by them. However, purely descriptive accounts of these events are insufficient, for the question as to which are truly relevant would remain unanswered. There are too many teaching behaviors that can be described ranging from a single eye contact that may be of little importance to complex sequences that lead to acquisition of highly complex behaviors. Mere description of these classroom activities, whatever they turn out to be, would be next to worthless, in a theory of instruction, unless their relationship to student behaviors can be established.

The specification of the relationship between the teacher's activities and the learner's outcomes is more complex than it seems on the surface. Teacher activities do not usually result directly in student learning. More often they direct the learner into certain activities to the exclusion of others. So it is important to know both what the teacher activities cause the learner to do and what learning outcomes result from what the learner does.

Again there is a qualification - what the learner does may range from acts which have little direct bearing on learning (as perhaps, a moment of distraction might be) to a search pattern which inevitably results in a learning outcome. Thus, while some of the learner's behaviors give "birth to learning," others oppose the process, i.e., they keep him from learning, and still others have no functional relationship whatsoever to learning. We need to have, in operational terms, a taxonomy of those activities that clearly favor learning and those which do not, and, as importantly, of the conditions under which each is likely to occur, together with the most likely behavioral consequences.

For economy's sake it is necessary that some conceptualization of the learner's activities be made. If not there would only be a fragmented series of events which would take years to unscramble or to weave into a coordinated theory. Accordingly, psychologists such as Gagne have emphasized learning outcomes with parallel prescriptions for instruction. Others, such as Ausubel, have tended to emphasize making material meaningful and thereby emphasize learning processes.

The present theory is an initial attempt to integrate the two positions. On the one hand, it ambitiously outlines what the learner must accomplish from the first viewing of the subject matter to the termination of an experience that results in an outcome agreed upon by the educational community as educationally relevant. Into this overall view the experiences of the learner have been arranged into a system comprised of processes that are prerequisite to or supportive of learning and processes that result directly in learning. These can be easily paralleled by teaching processes that lay the groundwork for learning and teaching processes that result in changes in the learner's behavior specific to some objective. On the other hand, this theory stipulates that there is a hierarchy of learning outcomes. However, the hierarchy is unlike that described by Gagne and others, since it is a hierarchy comprised of both processes (called transformations) and products (called learning outcomes). At each hierarchical level the theory provides implications for what the instructor must do to aid the learner, for what can be expected in terms of learner activity, and for the kind of outcome that can be achieved at a given level. While these have not been spelled out in full detail at this juncture, it is an important task for further development of the theory.

In addition, instructional strategies based on this theory would necessarily consider the trait-status of the learner. Thus, while a first grade pupil can be engaged in problem-solving activity, such as solving a mechanical puzzle, it must of necessity be quite different from the problem-solving activity of the adult looking for ways to fight environmental pollution. It is true, nevertheless, that both engage in similar processes and, from the standpoint of learning a problem-solving strategy, one is probably the precursor of the other. The child's problem-solving emphasizes process; but, in addition, the adult's problem-solving must take place against a rich backdrop of knowledge from which a selection of facts must be made. Accordingly, while some principles of teaching will hold for both, differentiations must be made, in terms of the age-status of each group, in the teaching process. There are other classes of differences that must be considered particularly in terms of the traits (i.e., more or less permanent dispositions) of the learner. Consistencies in the person's environment, learning experiences, and experienced reinforcement contingencies result in behavioral tendencies that predispose the person (i.e., make him more sensitive) to react to certain stimuli in the environment over others; to employ some strategies of processing information more than others; or to react with given affective (e.g., anxiety), attitudinal (e.g., dogmatism) or attribution (e.g., locus of control) tendencies. Some of these tendencies can seriously impair learning under "normal" instructional settings, while they may be facilitative under methods that adapt to these predispositions. Presumably, with more precise theories, better measuring instruments than are now available, and growing bodies of empirical evidence, educational methods can be especially tailored to overcome such difficulties. Stated more constructively, instructional strategies must be matched with individual differences in an effective instructional system, and the present theory has been developed to include such considerations.

An instructional strategy is a metaplan. To paraphrase Miller, Galanter and Pribram (1960, p. 16) it is a hierarchical process employed by the teacher to control the order in which a sequence of operations is to be performed. Thus, the strategy acts as a guide for manipulating stimuli and for transmitting these stimuli in a way that will effectively modify the behavior of another person according to some prestated terminal objective.

Instruction as Communication

The characteristics of the instructional process bear some resemblance to those of the communication process as described by Hovland (1953) and summarized in Fig. 1-1. The plan, which may be compared to a computer program, with its strategies and tactics, is stored in the *transmitter of the message*, whether communicator, instructor, or computer. The flow of the *content of the communication*, of the arguments or appeals intended to promote attitude change, and of the course content intended to enhance the student's cognitive skills, is channeled, sequenced, structured, and organized according to the plan.

The *executive function* of the plan governs which of the sub-routines (tactics) will be performed at any one time, thereby providing considerable flexibility in the implementation of the plan from one occasion to the next. The extent to which a message is processed, how it is processed, or even whether processing can or will be attempted depends in large part on the *predispositions of the audience* or student, that is, on individual differences in social motives, personality factors, and intellectual ability characteristics. The effectiveness of a strategy is determined, and changes within it are made by *evaluating the outcomes*. In the final analysis, evaluation must always be based, explicitly or implicitly, on the behaviors of the recipient of the communication, that is, the student.

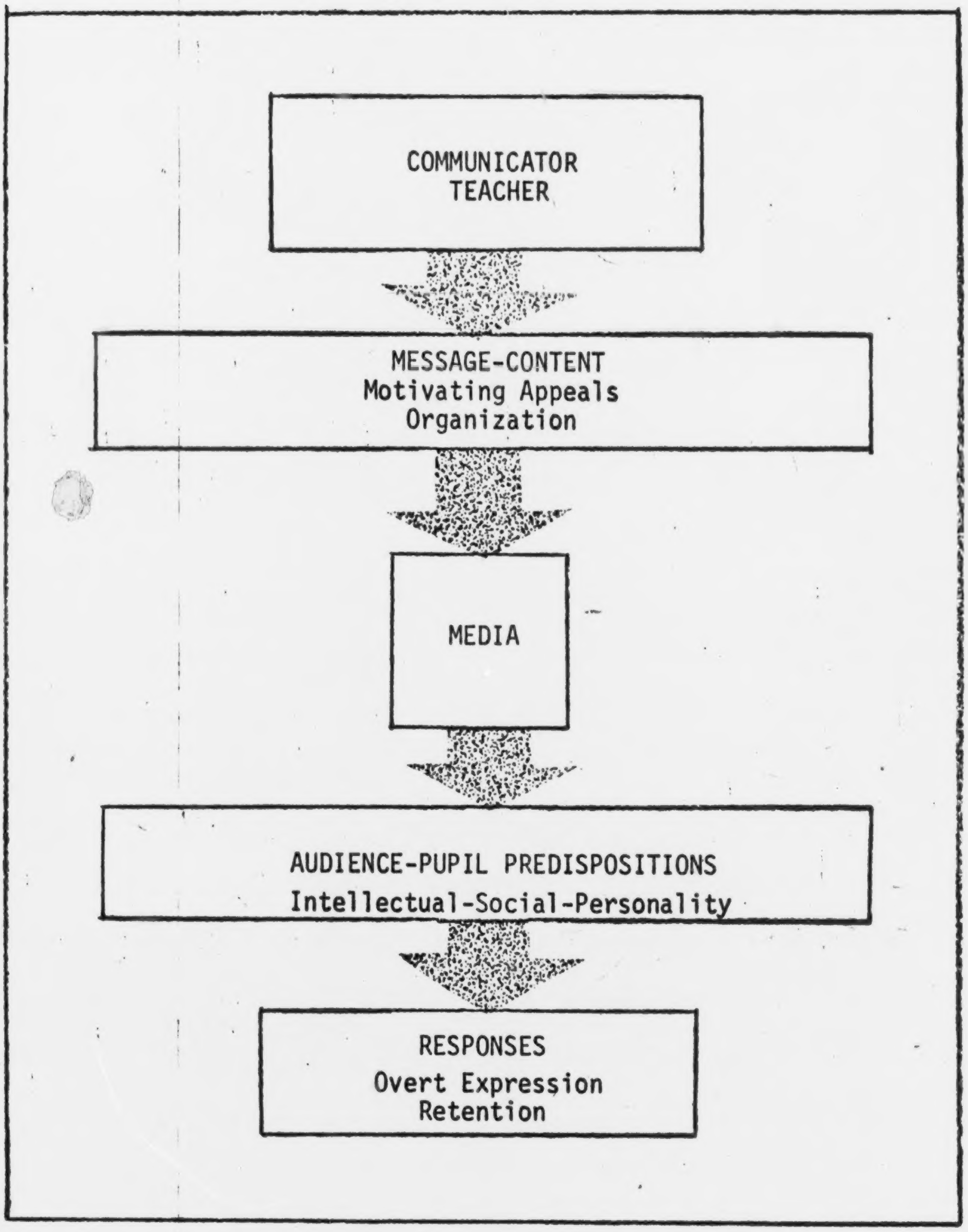
COMMUNICATOR
TEACHER
MESSAGE-CONTENT
Motivating Appeals
Organization
MEDIA
AUDIENCE-PUPIL PREDISPOSITIONS
Intellectual-Social-Personality
RESPONSES
Overt Expression
Retention

Fig. 1-1. Instruction as communication. This analogue is mainly a convenient basis for classifying variables that influence effective instruction, its main advantage being that all parts are external and observable.

Research within this orientation is typically concerned with the main effects of such conditions as those which belong to the classes of situational, state, and behavioral variables. Accordingly, certain general inferences or hypotheses about the instructional process become apparent and immediately available as topics for educational research. Thus, for examples: The personality of the instructor ... his trustworthiness, and his expertise ... and the cues he provides or the lack of them (as for example, in computer-assisted instruction) can influence the acceptance of a communication. Implicit in the communication content is it's ability to arouse motivation or uncertainty in the recipient. Material logically or psychologically sequenced, arranged in hierarchical fashion on the basis of end- products of learning or on the basis of intellectual skills (Ausubel, 1968; Gagne, 1970); or presented in a motor, ikonic, or symbolic mode will make decidedly different contributions to the end-products of learning. Information about these topics should ultimately feed back into the instructional process to affect decisions that must be made as a part of the instructional strategy.

A Model for Research on Learning and Instruction

This general orientation can be extended by incorporating the interactions between and among these variables into the research program. Perhaps the single most widely publicized of these interactions, at the present time, is the so-called aptitude by treatment interaction (ATI) implying that instructional methods are most efficient when matched with individual differences whether in the form of personality or intellectual variables. Walberg (1970) suggests a model very similar to that described here, with, perhaps, somewhat more emphasis on environment, though instructional variables must be included by definition. His formulation, as does the present one, asks such questions as (Walberg, 1970, p. 187):

1. Which instruction best promotes learning?
   (f_1 = summative evaluation.)
2. Which students learn best?
   (f_2 = studies of prediction and selection.)
3. Which environments best promote learning?
   (f_3 = stimulation and enrichment.)

A model representing the relationships among these variables and of their interactions are summarized in the following equations (Walberg, 1970):

$$L_h = f(I_i, A_j, E_k)$$

$$L_h = f_1(I_i)+f_2(A_j)+f_3(E_k)+f_4(I_iA_j)+f_5(I_iE_k)+f_6(A_jE_k)+f_7(I_iA_jE_k).$$

Aptitude by Treatment Interactions

In typical statements of the aptitude by treatment interaction, which specify relatively straightforward functional relationships, only the behaviors of the student in response to the task are considered in a description of the dependent variables (i.e., criterion performance). Further consideration of this point suggests that certain instructional and study activities must also be brought into the model and thereby raises another series of questions related to decisions an instructor must make, as follows:

1. What is it that sutdents do while the instructor is "instructing?"
2. What activities do students engage in between the time of onset of instruction and the elicitation of the criterial or terminal performance? How do these activities affect performance?
3. If such student behaviors are important to learning, what can the instructor do to manipulate such behaviors to maximize performance?

These questions tend to place the research emphasis on student activities which affect processing for storage and retrieval of information. They bring to the fore note-taking, verbal responding (e.g., directed student response, self-verbalization, and verbalization to peers) and test-taking as major instrumental activities. These instrumentations appear to have two roles in the student's behavior: They may be viewed as possible *terminal* activities (for example, instructional variables can and do affect the *kind* of notes students take or the kinds of study activities they engage in before taking tests); or as *mediating activities* which transform performance characteristics ordinarily elicited by given instructional variables (for example, the student who prepares for a multiple-choice examination probably achieves quite different objectives than one who studies for an essay examination). In either role, these activities can be modified by aptitudes and/or can modify further the influence of aptitudes on performance characteristics. Thus, it can be seen, that the student's instrumental activities may be considered as independent variables, as mediating variables, or as dependent variables influenced by and being influenced by aptitudes or individual differences.

While this approach appears to be a fruitful one, in the sense of its potential for generating a number of studies on variables related to instructional strategies, it is a relatively static model. A critical examination of it calls attention to the *dynamic properties* of learning which are noticeable by their absence. As a consequence of this orientation, it appears that *instructional variables* should be viewed as processes used by the instructor to set the stage for learning; *aptitudes* as readiness patterns which function as filters, or, more dynamically as catalysts, permitting the learner to benefit by certain environmental-instructional conditions but also to be hindered by others; instrumental activities as transformational mechanisms aimed at processing information for storage and retrieval; and learning criteria as achievements and end-products but also as abilities represented in the application, use, and retrieval of information.

A Dynamic Model of Learning and Instruction

In the course of conducting research in our laboratory, the latter notions about the characteristics of the learning-teaching situation have been extended into an even more detailed description of the learning process as it appears to function in an instructional setting. An attempt at a dynamic approach appears at this juncture to be more useful for guiding research than does the model previously described.

The present model is an evolving one. Accordingly, the presentation here must be considered as tentative. Whether the order of the stages and other details are accurate must be determined by further investigation. Nevertheless, the model, for the present, can serve as a means of summarizing the extant research, can point to variables which enter into decisions that eventually become a part of instructional strategy, and can point to areas which require further investigation. While, for the most part, the description here is of the dynamics of the learning process with occasional reference to instruction, the ultimate description should indicate parallel activities by the instructor.

An overview. The major stages that must be considered by the instructor are outlined in Fig. 1-2. Briefly, this sketch acknowledges

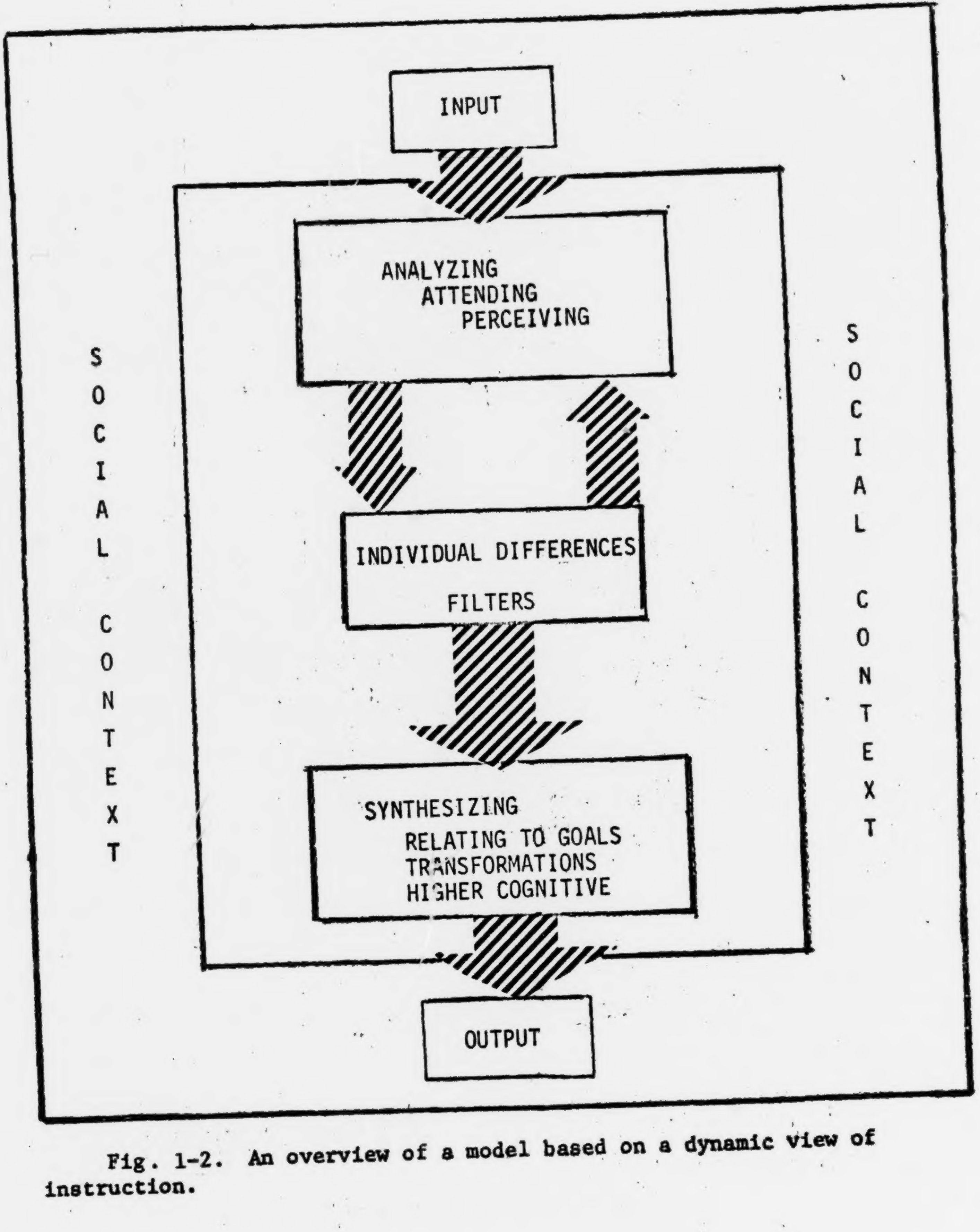
INPUT
ANALYZING
ATTENDING
PERCEIVING
SOCIAL CONTEXT
SOCIAL CONTEXT
INDIVIDUAL DIFFERENCES
FILTERS
SYNTHESIZING
RELATING TO GOALS
TRANSFORMATIONS
HIGHER COGNITIVE
OUTPUT

Fig. 1-2. An overview of a model based on a dynamic view of instruction.

an input by the teacher and output in the form of student behavior. Furthermore, it considers the social context within which the instructional process occurs. While these three classes of variables are ostensibly open to direct observation, the appearance is deceptive since the meanings of these variables, in the last analysis, must be implied.

Between the input and output are two major stages which can only be inferred. Nevertheless, they suggest a highly active, adapting, and dynamic organism since they suggest ways in which instructional materials are processed by the student. In the first stage, attending and perceiving are required for an analysis of the input. Individual differences (filters) determine whether the stimuli are or can be potentially meaningful ones. If not, there is further analysis provided the student is motivated to continue. If he is no longer motivated he would exit (literally or figuratively) from the learning situation.

Once particular stimuli are selected they are subjected to further processing for storage and retrieval in the synthesis stage. At this point, instructional materials take on interpretations which are idiosyncratic to the learner. Motivations, too, change character for they now seem to be peculiarly cognitive or epistemic in quality. Such notions as incongruity, dissonance, curiosity, uncertainty, and imbalance are employed to indicate that motivation is derived by a perceived discrepancy between the learner's present state and his anticipated state of achievement.

Transformation of the instructional material, however, is the principal processing that goes on during the synthesis stage. It can be as simple as mere association of the new material with a mnemonic device (as in the "30 days hath September" ... rhyme) or it can be as complex as integrating vast bodies of knowledge into a formula comprised of less than a half dozen symbols (e.g., $E = mc^2$). Whatever the transformation, the key word appears to be coding, the understanding of which may also be the key to the understanding of the higher mental processes.

The analysis stage. The details of the first stage of processing by the learner are depicted in Fig. 1-3. The input phase is entirely under the control of the instructor. What he does, and the decisions he makes at this point depends on his theory of instruction. The elements of this phase are essentially the same as those presented in the communication model. Research programs dealing only with this phase would be directed solely toward investigations of the effects of treatments. Accordingly, the main concern would be with the direct effects on student performance of such variables as sequencing of subject matter, types of advance organizers, modes of presentation, contextual cues, task difficulty, and characteristics of the instructor all of which are external to the student. An important feature of the present analysis is the recognition that whatever occurs at this point in instruction can only provide potential stimuli for the student. Oftentimes these are classified as nominal stimuli.

Before the stimuli from the input become effective there must be a considerable amount of preliminary processing. Initially, the message and accompanying stimuli must be registered. Accordingly, they must, at the least, be above threshold and salient to the learner. With this condition met, a degree of readiness in the form of a learning-set (e.g., curiosity or the need for achievement) provides the motivation for perceiving and attending; a process which culminates in focal attention. This means that all the features of a given situation are

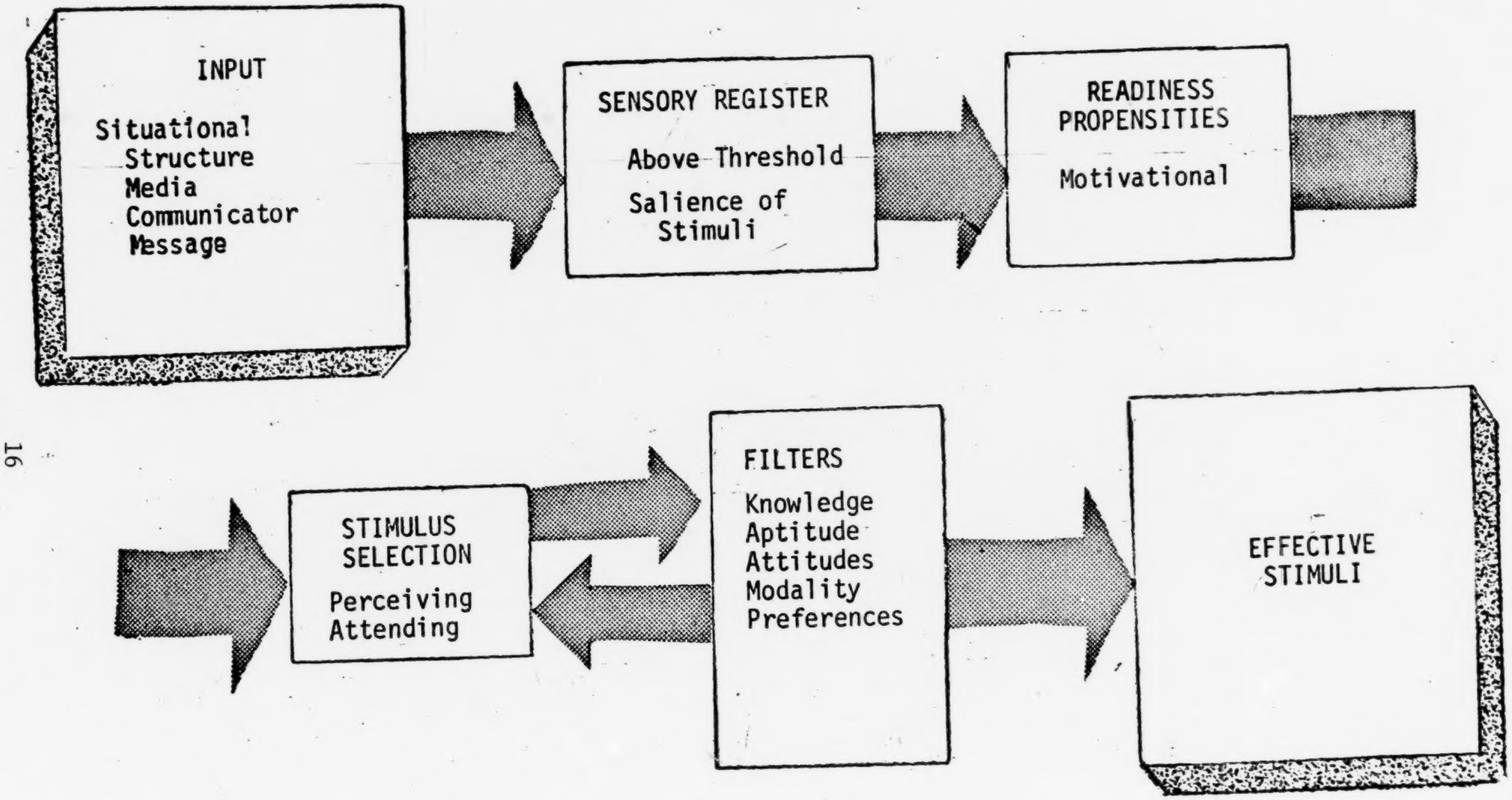
INPUT
Situational
Structure
Media
Communicator
Message
SENSORY REGISTER
Above Threshold
Salience of Stimuli
READINESS PROPENSITIES
Motivational
STIMULUS SELECTION
Perceiving
Attending
FILTERS
Knowledge
Aptitude
Attitudes
Modality
Preferences
EFFECTIVE STIMULI

Fig. 1-3. The analysis stage in processing materials in instruction and learning.

not automatic elicitors of behavior. More likely they are optional: Which structural features are attended to, and the method of analysis employed, differ from person to person.

The features that are selected by different observers or by the same observer at different times are assumed to be, in large part, a function of the filter-system, which is comprised of all so-called individual differences variables. As an illustration, differences in acquired knowledges or aptitudes differentially determine the effective stimuli. If the stimuli cannot be analyzed, they do not become effective. Recycling may be necessary between the filter and the perceptual-attending system until a pattern is constructed. The exact characteristics of the pattern are left unspecified but they may emerge as figure-ground or as meaningful dimensions. Because different features are selected for attention, analysis is a constructive act. Thus, there will be considerable variability, among students in a class, in what they observe even though they experience the same input.

Effective stimuli. The effective stimuli, or constructed pattern, result from the attentive-perceptive mechanisms. They comprise the common link between the analysis and synthesis stage. Under carefully prescribed environmental conditions, such as those that are obtained in classical-conditioning laboratories, the behavior predicted from the input would closely approximate that predicted from the effective stimuli; maximum differences would be obtained when the input is highly ambiguous. In general, the less-prescribed the external controls, the more opportunity there will be for idiosyncratic selections of stimuli from which configural patterns will be formed. The notion of effective stimuli includes the idea of "interpretation of the situation" thereby taking into account the phenomenological experiences of the student in the learning situation. (The relationship between the effective stimuli and interpretation should, probably, be represented by a link or, perhaps, by a feedback loop in the diagram.) The interpretation is that part of the effective stimulus pattern which is comprised of task demands as implied form the task itself or from instructions; goal expectations which result from prior experiences and are therefore influenced by the filter system; and processing strategy preferences. Thus, the effective configural pattern to which the student reacts is comprised of selected stimuli from course material or course content and of expectations regarding desired outcomes. The incorporation of expectations into this part of the model appears especially important to explain differences that occur among students in the kinds of transformations they use.

The synthesis stage. A student in a learning situation has at least two behavioral alternatives during the analysis stage: either he exits from the situation or he processes the information. In the latter alternative certain features of the input are selected, as already described. Then, in the synthesis stage, these stimuli are put into a perspective consonant with his interpretations of the learning situation (i.e., What is expected of him by the instructor? How long is the material to be retained? What kinds of goals are to be achieved? and so on). Once this point has been reached the input is encoded; it is categorized, (which may require nothing more than recognition of the item), elaborated, or otherwise synthesized. *What* is synthesized need not be clear or distinct as already noted. It is the synthesis that contributes to clarity. (See Fig. 1-4.)

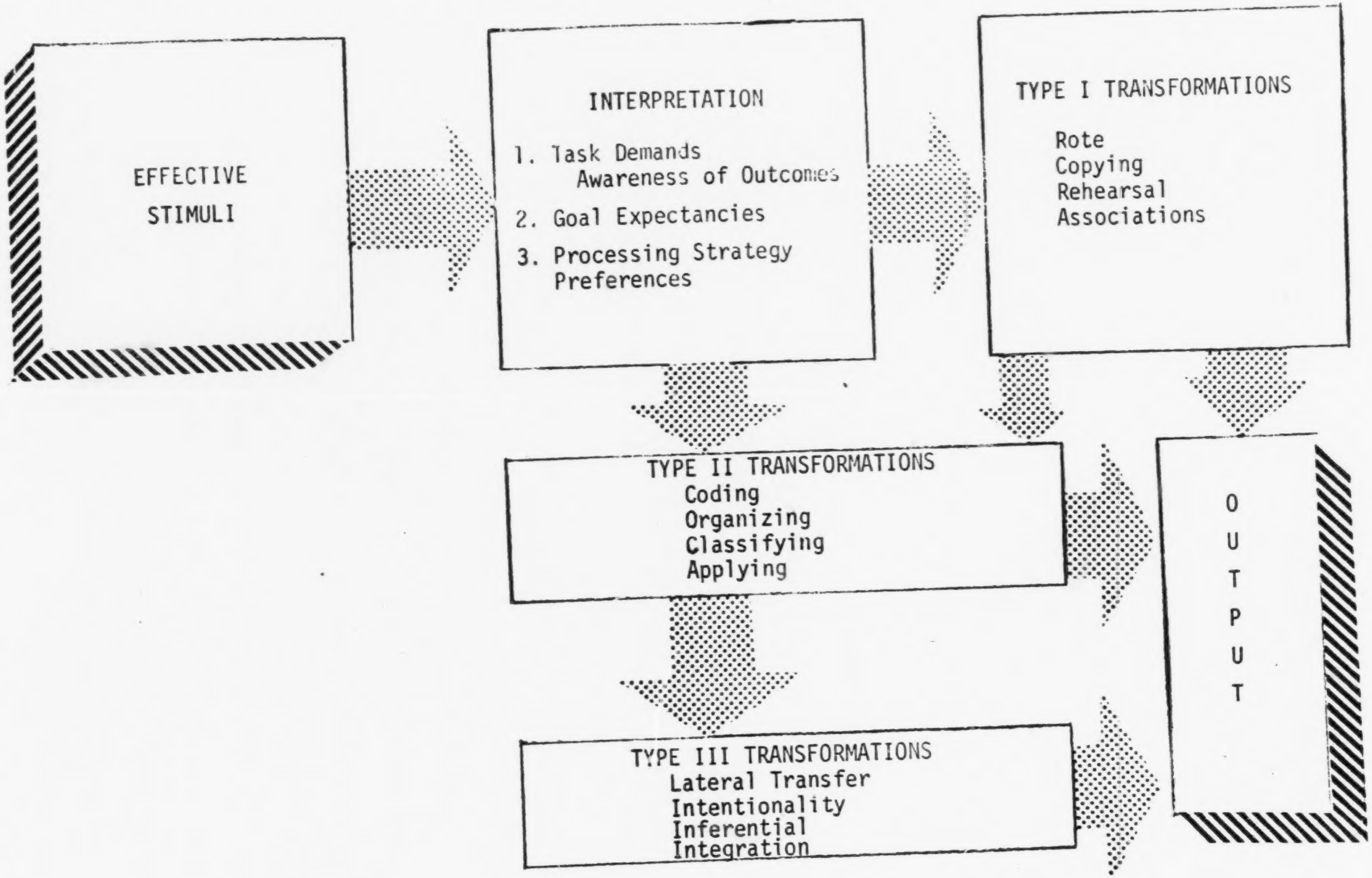
EFFECTIVE STIMULI
INTERPRETATION
1. Task Demands
Awareness of Outcomes
2. Goal Expectancies
3. Processing Strategy Preferences
TYPE I TRANSFORMATIONS
Rote
Copying
Rehearsal
Associations
TYPE II TRANSFORMATIONS
Coding
Organizing
Classifying
Applying
TYPE III TRANSFORMATIONS
Lateral Transfer
Intentionality
Inferential
Integration
OUTPUT

Fig. 1-4. The synthesizing and storage phases of instruction and learners.

How the input is synthesized, or the extent to which it is synthesized, depends in large part on the student's expectations (interpretations). These appear to direct further processing of the input as part of their executive function. Expectations may be in several forms: Task demands can be implied from instructions, from assignments, from the demand characteristics of an experiment, and from characteristics of the task (e.g., problem-solving vs. memorizing a poem). Goal expectancies relate one's performance to the criteria or standard characterizing the terminal performance. They may range from the desire to reach a high standard of excellence by the student with high need for achievement or satisfaction with a mediocre performance by students with low need for achievement. Students with previous experiences of success may try to reach realistically higher goals than previously; those with previous experiences of failure may set unrealistically high or low goals. Goal expectancies may be imparted directly to the student when he is instructed on such matters as the kinds of tests he will be given, or when he is given certain kinds of advance organizers, or when certain grading provisions are specified. They are also influenced by the social context in which learning occurs, and by the normative standards of one's peers or peer group. Finally, expectancies can be affected by *learned* preferences for one learning strategy over another. Thus, a student who succeeds at rote memorization may view all tasks as being most successfully approached through rote memory while another student may try to encode all materials in meaningful ways.

Interpretation, as it is being employed here, always involves the weighing of what must be done with the material against the criterion to be reached. By this definition, interpretation determines what will be done with the materials. A wide range of instrumental activities may be employed for reconstructing the effective stimuli into patterns that will implement the goal activities suggested by the interpretations. All essential processing activities in this phase are related to transformation of the incoming stimuli. For convenience in the present account, the kinds of transformations have been classified at three levels, and are presumed to be arranged hierarchically according to complexity. This arrangement implies the desirability of sequencing instruction in ways that parallel these kinds of transformations. The aim served by the transformation is to store the material in a form that will lessen memory load and that will make it available for later retrieval.

The transformations at Level I are relatively primitive. For convenience, the transformations at this level are called associative because they appear to consist mainlv of arbitrary associations within the material itself (for example, linking one sentence to another). In general, the modification bears some resemblance to the new learning or at least is only a step away from the new learning as, for example, they might be in a free association task. The student predisposed to process material at this level may attempt to memorize materials on rote, verbatim, or arbitrary bases; he may attempt to form some elementary images of the material; or he may make some relatively low level associations. These processes are similar to those used in "cramming" for example, where the student may expect to take a test requiring only recall, to retain the material for only a brief period of time or where he will be satisfied with minimal achievements. It should be noted that students whose interpretations require more advanced levels of transformations probably must master Level I transformations first. Overlearning, repetition, practice, rehearsal, and copying are important instrumental activities at Level I if the student is to master information, to retain it, and to protect it against interference. Retrieval of information here is typically of the recall or recognition variety. Interference (i.e., retroactive and proactive inhibitions) is its greatest enemy.

Level II transformations involve attempts to make the material meaningful. These are constructive transformations. Modifications at Level II are similar to the content of experience only on an abstract dimension. The most typical example of Level II transformations is concept-formation. In principle, these transformations code the material in a form that approximates exisiting cognitive structure. They are constructive in the sense that new organizations (for the student) of ideas are often achieved. Thus, for example, the learner may organize the new learning in terms of existing concepts, he may acquire a new classification (concept), or he may find an application for the learning. The instrumental activities for constructive transformations are encoding according to arbitrary mnemonic systems (the very lowest level), encoding according to thematic schemes, encoding in terms of existing cognitive structures, classifying what is learned, and organizing material in logically sequenced ways. Retrieval of information at this level is dependent on cues that aid in identifying the correct plan or "storage area."

Level III transformations are inventive. As a class they comprise the epitome of the higher mental processes. These transformations represent a major leap from the form of the original learning experience and often bear no resemblance to it. In lateral transfer, for example, the person generalizes over a broad set of situations at the same level of complexity as he would when learning the relation between two sides of a right triangle and transferring it when seeing, for the first time, a problem in physics relating to acceleration of a body rolling down an inclined plane (Gagne, 1970, p. 335). Characteristic of Level III transformation is the testing of alternatives to arrive at unique implications or unique organizations of material already acquired by the learner. Included at this level are such behaviors as the identification of new relationships among concepts (i.e., principle-formation) and the identification of a unique solution to a problem. Hence, we speak here of intentionality, inferential processing, integration, and restructuring. Level III transformations, at the highest level of development, must be considered integrative, inventive, productive and constructive. The learner at this level engaged in behaviors which emerge as novel sequences and which are reproduced in easily communicable plans comprised of clearly defined hierarchical arrangements of behavioral units.

Output

Ideally, the behavioral output will reflect the expectations of the learner and the transformations he employs. There are numerous possibilities that might be enumerated here but will not be because they have not been developed sufficiently. Others are omitted because they require further exploration. However, it can be noted briefly that output may be defined in terms of type of test (e.g., recall or recognition); kind of end-product (e.g., motor-skill, attitude, or concept); kind of intellectual skill (e.g., learning-to-learn, learning-to-perceive, or learning to test the alternatives); or in terms of the characteristics of the terminal performance (e.g., fast or slow, or higher or lower, than previous performance). Which of these is used by the instructor or investigator will be determined by the decision about what is to be tapped ... the effects of selective perception? of expectations? or of transformations?

Epilogue

The model presented here and the considerations it highlights points to a sort of hierarchy of learning processes including attending, perceiving, discriminating, selecting, and transforming. All of these are processes assumed to be essential facets of the learner's activities. Further elaboration of this model will require: specification of stages that can be influenced by instruction and the kinds of instructional activities that are required to facilitate learning at each of these stages; a more complete specification, than is currently available, of the kinds and characteristics of instrumental activities in which the learner can engage at each stage of learning to reach specified terminal objectives; and a more detailed specification of the kind of outcomes than can be expected at each of the phases described above. Some progress has been made in each of these areas but further elaboration must depend upon additional empirical evidence.

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Chapter Two

Cognitive Stimulation in Instructional Strategies

Charles B. Schultz

Researchers, administrators, and teachers who are non-participants in the learning side of the instructional process are apt to overlook the sheer amount of time students spend in educational settings. At least 150 years of Sunday sermons are concentrated into the child's first six years of schooling (Jackson, 1968), a comparison which would challenge the most imaginative preacher were he faced with the prospect of teaching. Moreover, it is typically expected that students will devote most of their time in school to the demanding and sometimes unreasonable tasks required for academic learning. In this light, a major instructional problem is initiating and maintaining student interest. Unfortunately, there has been little systematic information that the motivational theorist or researcher has contributed toward the solution (Maehr and Sjogen, 1971).

Nevertheless, students do progress; they master complex skills and acquire large amounts of knowledge. Just as extrinsic rewards maintain performance of animal subjects in learning experiments, complex systems of social reinforcers influence learner behavior in instructional settings. While these reward systems may keep students laboring at the task of learning, the problem is that they do not appear to arouse an enduring interest in learning as a worthwhile activity in it's own right (Coleman, 1961) or to contribute to the growth of curiosity (Day, 1968). Indeed, the school has been criticized on just this count. It has been viewed as intellectually barren (Silberman, 1970) and as stifling curiosity with an overemphasis on discipline, management chores, and rote learning, with instructions beyond the learner's level of understanding, and with long periods of physical inactivity (Marx, 1967).

The failure to arouse an interest in learning may be due in part to what is actually rewarded in school settings. Relatively small amounts of social reinforcement are conferred on scholarship compared to the amounts given to success in athletics or physical attractiveness (Coleman, 1961). In fact, the classroom reinforcement contingencies are such that rewards are obtained for not going beyond the assignment, for evasion of academic tasks, and for conformity (Marx, 1967).

The problem of arousing interest in learning could be attacked directly; that is, instructional tasks could be designed so that the act of learning itself becomes a source of satisfaction and reward. This emphasis on intrinsic motivation may be advisable not only because of the difficulty involved in changing the reward systems of the school and other social institutions which influence the young, but because extrinsic systems of reward may interfere with the development of intrinsic interest in learning (Bruner, 1963; Maddi, 1961; Harlow, 1953; Hunt, 1965).

Intrinsically motivated behavior occurs when experience does not match up with expectations. It is the result of the unexpected, the unusual, the novel and, in general, continues until the discrepancy between experience and expectation is reduced or otherwise resolved.

Consider the instructor who called his students' attention to the discovery of the Kensington Stone in Minnesota (Fenton, 1966). The message on the stone slab was carved in runic letters and dated 1362. Translations of the ancient Scandinavian language indicated that the stone was left by an expeditionary party of Swedes and Norwegians who met with disaster in the new world. In this case, what the student has just experienced (i.e., the informational input) is discrepant with what he has come to expect (i.e., his prior learning) regarding the discovery of America. There is considerable evidence that discrepancies between informational inputs and prior learning or expectancies arouse a search for relevant information (Berlyne, 1960, 1963, 1965b). One might get an intuitive "feel" for the relatively potent motivational effect of discrepancy by comparing his interest in studying a passage containing detailed information about the Kensington Stone if it were dated in 1362 with his interest if it were dated in 1762.

In trying to learn more about the Kensington Stone, the student could resort to instrumental activities such as asking questions, reading or thinking about the information given him. If, as a result of this effort, the authenticity of the stone is found to be highly questionable, the discrepancy experienced by the learner is reduced. The stone is a fake and he was right about Columbus all along. If, on the other hand, the stone's authenticity is upheld to his satisfaction, the learner is left to search for more information (e.g., the accuracy of the translation of the characters), to rationalize away the discrepancy (e.g., the problem is of little concern to him) or to be "nagged" by the unresolved problem. Thus, the individual responds to the discrepancy by seeking or using information and receives feedback from his responses which may have the effect of ending his informational search or of maintaining it.

The essential features of a relatively simplified example of cognitive stimulation have been outlined above. They can be summarized as follows: When there is a discrepancy between input and expectancy, the organism is aroused or activated. This state stimulates instrumental responses intended to reduce the discrepancy. These responses may result in the alteration of the environment or the organism's cognitive structure. In either event, new input or new standards are fed back into the system, which may recycle until the discrepancy is reduced.

Cognitive stimulation is the activation of a system of intrinsic motivation which has as its essential feature the discrepancy between expectation and experience. The discrepancy notion is not a new one. In fact, it is claimed by a number of different theoretical formulations as a source of motivation. For example, Berlyne (1960, 1963) developed a drive reduction model of curiosity in which the curiosity drive is initiated by the collative properties of the stimuli. Collative properties are those components of the stimuli which invite comparison; they are surprising, novel, incongruous, or otherwise different from what an individual has learned to expect. In the present context, they and the expectancies they violate are discrepancies.

Organisms which attempt to reduce a drive initiated by the collative properties, attempt to maintain a state of balance or consistency by reducing discrepancies. In this regard, Berlyne's theory of curiosity drive is similar to cognitive consistency theory. Consistency theory, whether stated in terms of congruity-incongruity (Osgood and

Tannenbaum, 1955), balance-imbalance (Abelson and Rosenbaum, 1960; Heider, 1946), or consonance-dissonance (Festinger, 1957, 1964), assumes that the organism strives to make harmony out of disharmony. Thus, incongruity, imbalance, and dissonance are accorded motivational properties although the details of the motivational mechanisms are seldom specified. The information processing model (Hunt, 1965; Guilford, 1965; Miller, Galanter, Pribram, 1960; Simon, 1967; Taylor, 1960) though similar to other balance models compares human cognitive processes over a range of control devices from simple thermostats to complex computers. According to this approach, the organism tests for differences between input (i.e., for differences in room temperature) and standards or goals (i.e., thermostat setting). When differences are detected, the organism operates (i.e., heater on) to reduce the differences. The results of the operations (i.e., changes in room temperature) are fed back into the system to be tested against the standard and, accordingly, the operation is continued or ended.

The similarity of these formulations to the notion of cognitive stimulation is apparent. However, there are differences. The conception of cognitive stimulation described earlier does not include (a) the drive reduction notion of Berlyne's theory; (b) the emphasis placed on the affective consequences of discrepancy by the consistency theorists; or (c) the lack of concern by some information processors for the initiation of behavior. Even so, the present discussion draws heavily on all three theories to provide knowledge about psychological mechanisms which may facilitate instructional decision-making.

The remainder of this chapter is an elaboration of the system of cognitive stimulation outlined above. The focal point of the discussion will be on those elements involved in the activation of the learner, i.e., on the input, the expectation, and on their combined effect, the discrepancy. Other matters, such as the effect of expectations on the direction of learning (Chapter III), the transformation of stimulus input (Chapter IV), and the learner's instrumental activities (Chapter V), will be considered in detail elsewhere.

The Input

Stimulus input has properties which arouse interest over and beyond its intensity or affective value. These properties depend on what Berlyne has called the collative content of the stimuli. One way of thinking about collative content is that it is inversely related to the redundancy of the stimuli. The more one part of the stimulus configuration "tells" about other parts, the lower the collative content. A critical feature of collative content, then, is the extent to which elements of the stimulus field are different or discrepant from other elements in the same field or with stimuli experienced in the past. The former condition refers to the complexity of the stimulus input and the latter to its novelty. Thus, complexity and novelty are collative properties which are associated with the order in which discrepant elements are presented.

Discrepant elements may be presented successively (element A then element B) or simultaneously (element A and element B). Dember and Earl (1957) and Fiske and Maddi (1961) make a similar distinction between temporal and spatial presentations of stimuli. Simultaneous presentation can be illustrated with the following example of discovery learning. High school students were given physical maps of mid-western United

States with instructions to find out where the major cities were located. As they examined the maps, several places may have "competed" in their minds for the locations of important urban concentrations. In terms of the present discussion, the competing locations for a particular city are discrepant elements which were simultaneously presented to the learners.

Typically, when discrepant elements of stimulus input are simultaneously presented, their collative properties can be described in terms of their complexity, i.e., as a heterogeneous stimulus array composed of elements which vary in their features and relationships. In the above illustration, such elements are represented by shorelines, mountains, and rivers. The relationship may be apparent either in the pattern (i.e., arrangement of the elements) or in the meanings, principles, or rules that the learner brings to the stimulus. Thus the complexity of the map elements varies according to the detail used in representing mid-western topography. The complexity of the relationships among the elements depends, in part, upon the number and type of principles of urban settlement (e.g., settlement requires intersections of transportation routes) that the student uses in approaching the problem.

Walker (1964) distinguished between surface and potential complexity. When the elements of the stimuli are more complex than their relationships, the overall stimulus pattern is characterized by surface complexity. On the other hand, potential complexity is the inverse condition: the relationships are more complex than the elements. Surface complexity may evoke fixation responses or examination of the physical features of the stimuli and, thereby, provide the motivational basis for elementary kinds of learning such as letter recognition. However, most academic learning involves potential complexity. It is a condition in which the learners can "do more with" the stimuli (Walker, 1964). Instructors can direct learners toward either the surface or potential complexity of the learning task. In the example described earlier, the problem was presented so that the complexity of the relationships among the elements was emphasized. On the other hand, surface complexity would be implied when the learner, who was given the same physical map of the mid-west was asked, "Where is a mountain?"

When discrepant elements of stimulus input are presented successively, their collative content is typically novel in character, i.e., it is the new or different portions of the most recent input. The reference to teaching about the Kensington Stone illustrates how novelty is implied by successive presentation. Since the learner had already acquired the "knowledge" that Columbus discovered America, input to the effect that Scandinavian explorers preceded him is novel.

Although stimuli may be completely new to the learner, most adults or even older children rarely encounter a stimulus which is absolutely new in all of its characteristics. In most cases, a "new" stimulus contains familiar elements in a new arrangement or combination. Since a stimulus can be absolutely new only once, with repeated presentations it invariably looses its capacity to arouse interest. However, when its absolute novelty "wears off," the stimulus may still have the potential for relative novelty due to its arrangement, placement, or context. For example, learners may have encountered the notion of equilibrium in science often enough for it to lose its novelty.

However, when the same concept is encountered in economics, its new-found novelty is based on its new context.

The current input does not have to be identical to previously encountered stimuli for a loss of novelty to occur. Due to stimulus generalization, the learner compares the input against a range of past inputs which share varying amounts of common attributes along any one of a number of dimensions. If novel stimuli are to be selected for instructional use, the most important of these dimensions must be considered. Similarity also refers to the context in which the stimulus of interest occurs (Fiske and Maddi, 1961). If, for example, the equilibrium notion were first taught in chemistry, encountering it in physics would not be as novel as encountering it in economics.

The Expectation

The same stimulus pattern will not arouse the same interest in a learner from one time to another or the same interest in different learners at any given time. That is to say, cognitive stimulation is not a simple function of the complexity or novelty of the stimulus properties alone. Rather, stimuli interact with or are modified by the state of the organism (Berlyne, 1960; Dember and Earl, 1957; Hunt, 1965; Munsinger and Kessen, 1964). In particular, the stimulus interacts with what the learner has come to expect through prior experience. Expectations may be conceived of as plans or sets (Hunt, 1965), as adaptation levels (Haber, 1958; McClelland, 1953), or as any prior stimulation (Dember and Earl, 1957). Whatever the formulation, expectations are the result of previous learning or experience, and as such are subject to modification by the instructor. At least three types of expectancies can be identified: ongoing-input, representations, and generalizations.

Ongoing-input Standard

At the most elementary level, current stimulation serves as the standard for the input which follows (Hunt, 1963, 1965). Thus, any stimulus change - the onset, modification, or cecession of input - is a discrepancy from the immediately previous stimulation. While attempts have been made to explain all exploratory behavior in terms of stimulus change (Dember and Earl, 1957), violations of expectancies based on ongoing-input are most directly associated with eliciting the orienting reaction (Berlyne, 1960, 1963; Lynn, 1966; Maltzman, 1967), or what Pavlov (1927) called the investigatory or "what-is-it" reflex. The orienting reaction is a system of "somatic" responses which tend to increase the individual's responsiveness to his environment (Maltzman, 1967). For instructional purposes, the critical function of orienting reactions is to render the learner receptive to information.

There is evidence from laboratory experiments that changes in the ongoing stimulus input evokes orienting responses in human subjects (Davis, Buchwald, & Frankmann,1955; Lynn, 1966; Maltzman, 1967). The tempting "conceptual leap" from these studies to instructional settings is that learners, too, will be more attentive to, interested in, and therefore learn more from conditions which are variable rather than constant. This proposition is certainly consistent with the educational lore, the essence of which is, "give 'em variety." Much of the control of variety or variability rests in the hands of the teacher and may even be a source of individual differences among them. In this regard, Coats and Smidchens (1966) found that college undergraduates learned more from a "dynamic" lecturer than from a "static" speaker. The static instructor read from a manuscript, made no gestures or eye contact, and held vocal inflection to a minimum while the dynamic speaker delivered the same lecture from memory and used much vocal inflection, gesturing, eye contact, and animation.

Representational Standards

Representational standards are comprised of any pieces of information, (whether concepts, principles, or plans) which have been internalized and maintained in memory storage. They are intentional or informational in nature. Intentional representations are sequences of behavior or programs of action which have become internalized and integrated into the cognitive structure. These representations are comparable to what Miller, Galanter, and Pribram (1960) have called plans. We have plans for going to work, brushing teeth, writing chapters, for studying chapters, and for getting out of studying chapters. Once a plan is begun, it becomes a representation or an intention against which incoming stimuli are compared. A major consequence of a discrepancy between the intentional representation and the learner's circumstance is the initiation and maintenance of operations (responses) designed to complete the plan and thereby eliminate the discrepancy.

One type of discrepancy based on intentional representations is an interruption. Research on the motivating effects of interruptions (i.e., the Zeigarnik effect) may be interpreted as illustrations of the violation of intentional representations. Ovsiankina (1928) interrupted subjects as they performed her experimental task. The intentional representation "set up" by the initiation of the task was not met. Later, she provided them with the opportunity to complete the task without giving them instructions to do so. The majority of the subjects returned to the task and worked at it until it was complete, suggesting that discrepancy between intention and circumstance is motivating. An instructional illustration of the use of intentional representations is to make out-of-class assignments the completion of a task or problem which was begun in class.

Informational representations are the accumulated knowledge the learner has acquired. They are the substance or content of the cognitive structure and are comparable to what Miller, Galanter, and Pribram (1960) have called images. For example, a description of New York City which pictured a wooded, park-like scene would not square with the image most of us have of New York. Such stimuli are high in informational content precisely because they differ from the representations we have acquired through prior experience. In informational theoretic terms, a picture of congested buildings contains little or no information about New York while a picture of an expanse of woods, trees and grass does.

Violations of informational representations lead to the acquisition of information which may reduce the discrepancy. One of the most immediate and rich sources of information is the stimulus input which contradicted the informational representation. In the example above, the input is the ruralesque description of New York. It has been argued by Festinger (1957) that typically information which contradicts existing beliefs is not sought; in fact, it is avoided in order to minimize cognitive dissonance. However, research to support cognitive dissonance theory in this respect has been inconsistent at best (Freedman and Sears,1965).

One reason for the inconclusive findings may be that the dissonant belief also arouses the subjects' curiosity and therefore attracts him to it (Rhine, 1967). There is evidence to suggest that this is the case. Berlyne (1954) found that subjects learned more about animals which they judged as surprising (i.e., which violated their expectations) than about animals they did not judge as surprising. Presumably, violations of the informational representations led to a greater search for and acquisition of information. Schultz (1970) examined the effects of violating informational representations on time spent studying written material and on information learned. One group received bogus "evidence" which confirmed their existing beliefs regarding the outcomes of an attitude change experiment. A second group received "evidence" which contradicted their existing beliefs, i.e., it violated their informational representation. All subjects viewed pairs of slides which were simultaneously projected on a screen. On some slide-pairs, one member contained information which agreed with the subject's existing beliefs while the other contained discrepant information.

Violation of informational representations resulted in more time spent examining all slides and in higher test scores on the general topic than did confirmation of informational representations. Moreover, only the group whose expectations were violated appeared to find the descriptions of a position which contradicted their existing belief (i.e., their informational representations) interesting and a source of information. Their scores were consistently higher than the confirmation group on self-reports of interest in discrepant slides, the choice and examination of discrepant slides, and on scores of test items requiring knowledge of the discrepant position. Thus, violations of informational representations generate greater general interest in the topic than confirmation of expectancies and focus the learner's informational search on the informationally rich discrepant position. Contradiction of representations appears to be one condition which renders discrepant information attractive enough to risk increases in dissonance.

Informational representations vary in the amount of affective value attached to them. Some representations are critical for the maintenance of the learner's self-esteem or core elements in his belief system. Violations of these standards may have potent motivational effects. However, it may be precisely when commitment is high that the learner cannot afford to risk dissonance by examining the discrepant positions. Thus, increases in affective value may be directly related to interest in the general topic, but inversely related to interest in the discrepant position. One instructional moral of this hypothesis is that learners will examine the informationally rich discrepant input when it does not involve beliefs they hold dear and they will shy away from such information when it deals with a topic to which they are highly committed.

Generalized Standards

In order to violate representational standards, the instructor must *supply* information which disagrees with information the learner has acquired. The critical feature of violating generalized standards is the *withholding* of information due to the vagueness or ambiguity of the input or to its incompleteness. Sometimes the learner is faced with a confusing situation whose features do not contradict a specific fact, concept, or plan he has acquired. He may be confronted with an array of equally attractive alternatives or with a predicament for which no alternatives are readily available. For example, he may examine a picture of New York which is so out of focus that the features are not immediately recognizable. The blurred input does not violate a specific representation the learner has acquired because the information is so scant he is unable to "summon" an image of New York for comparison.

However, a discrepancy exists. The expectation in this case is a set or a generalized standard such as "objects (or pictures) should be recognizable" (Hunt, 1965). The blurred image of New York does not meet this expectation. Other examples of generalized standards are: the universe is orderly (violated by stimulus disarray), communications tend to be complete (violated by an incompletion), and events are caused (violated by an illusion). Generalized standards are more removed from concrete experience than are representations; they are abstracted from an accumulation of representations. The generalization that the universe is orderly is based on many experiences which were internally represented or maintained in memory storage and associated in such a way as to form a generalization. Thus, generalized standards require both experiences and representations of those experiences. Some generalized standards are pervasive enough to become relatively permanent personality dispositions. The dogmatic person, for example, has formed the generalization that the world is hostile or threatening and the person with an external locus of control has learned the generalization that what happens to him is the result of luck.

Violations of generalized standards appear to have the effect of arousing interest. In an experiment described earlier, Schultz (1970) also included an experimental treatment in which subjects received both evidence supporting and evidence contradicting their existing beliefs. This condition approximated the generalized standard expectancy by providing support for both beliefs rendering them equally attractive. More time was spent by subjects in this condition examining the experimental material than any others. They also had the highest overall test scores. However, they did not have the pronounced interest in the discrepant belief held by subjects who received only evidence supporting the discrepant belief. It seems that without the contradiction of an explicit representational standard, the learner's search for information is less focused and more diffused. In this regard, high affective value attached to the topic of the generalized standard may increase the level of information seeking. Unlike the contradiction of informational representations, the learner is not directly faced with the threat of having his existing beliefs overturned.

An important advantage of the expectancy notion is that it provides a common rubric for superficially different phenomena. Berlyne (1960, 1965b) argued that the stimulus change formulation of Dember and Earl (1957) only accounts for conditions in which the stimulus elements are contiguous. As a consequence, it is inadequate to explain discrepancies in which the inputs are separated in time or space. He argues further that Hunt's (1965) discrepancy hypothesis is dyadic, i.e., it is limited to the case in which discrepancies involve only two elements. The present formulation includes stimulus change as the ongoing-input standard and accounts for discrepant elements separated in time by the representational standard. In addition, the generalized standard accounts for discrepancies with multiple elements or with no discernible elements.

The Discrepancy

The ingredients of discrepancies, the input and the expectation, can be combined in a variety of ways to suggest different instructional applications. A few possibilities are illustrated below:

(a) Successive Presentation - Ongoing-input Standard. This combination has been referred to as stimulus variability. Coats and Smichens' (1966) research clearly suggests that the variability of teacher behavior has potent motivational effects on learners. Stimulus variability also can be capitalized on in schoolwide planning. Whatever other benefits or drawbacks they may have, adaptations of the Trump Plan offer valuable sources of stimulus variability in the form of large group-small group instruction, modular scheduling, team teaching and staff diversification, and even movable walls.

(b) Successive Presentation - Representational Standard. When the essential feature of the most recent input is its newness, novelty results. When the input has "shock value" due to its relatively sudden or abrupt appearance, the discrepancy is characterized by surprisingness. Berlyne (1965a) cites an inquiry lesson by Suchman with elementary school children which exemplified surprise. A demonstration was performed in which a brass ball was slipped through a ring which was barely larger than the ball. After the ball was heated, it sat on the ring instead of slipping through.

(c) *Simultaneous Presentation - Representational Standard*. This combination results in *incongruity*, a condition in which the input is composed of stimulus components which previously had not been associated. For example, the single stimulus of a bearded lady not only violates the representation that women are beardless, but the representation that it is men who have beards. Thus, the impact of incongruity draws heavily upon the incompatibility between representations of simultaneously presented stimulus elements. In other words, what makes the bearded lady of enough interest to display in side shows is not just that she differs from other women, but that she differs in a way that makes her man-like. Incongruity can be generated by the unlikely juxtapositioning of opposing elements as illustrated in the following topics: The sophisticated artistic expression of "primitive" groups, the liberalism of Barry Goldwater, or how FDR saved America from communism.

(d) *Simultaneous Presentation - Generalized Standard*. When the learner has before him a myriad of options or has no clear-cut alternative, he experiences a form of discrepancy called *bafflement*. The Anthropology Curriculum Study Project (Dethlefsen, circa 1966) developed an imaginative introductory unit for a secondary school anthropology course. Learners are shown a map of a camp site in the Kalahari Desert which contains the descriptions and placements of artifacts found at the site. The learner's task is to describe the life style of the people who lived there. Thus, a discrepancy is created between the generalization that "all people have a way of life" and the intuition that "the way of life of the people at the camp site is not readily apparent." As a result the learner is motivated to search the artifacts on the map for clues. Of course, the same lesson could be taught in a way in which discrepancies would be minimized. For example, the student simply could be given the map and told to learn about the artifacts or the instructor could lecture extensively about the details of the artifacts.

Discrepancy and Arousal

Why does the discrepancy between input and expectation push, pull, or prod the learner to act? The answer to this question involves the notion of arousal, an internal state which implies the activation of the organism and which is usually indexed by the complex of bodily responses associated with the orienting reaction. Even though the "signs" of arousal are generally agreed upon, the nature of arousal itself is far from certain and remains a subject of disagreement. For example, in Berlyne's (1960, 1963, 1965b, 1967) formulation, which was briefly described earlier, arousal is accorded a drive-like status. In contrast, Mandler (1964) treats arousal "entirely as a stimulus of varying intensity, rather than a drive" (p. 174).

Although the differences between Berlyne and Mandler are important issues for researchers interested in variables underlying motivation, they need not be of great concern to the instructional decision-maker. The important feature for instruction is the inferences that can be drawn from the research of the two investigators as follows: First, studies by both suggest that discrepancies are clearly associated with physiological changes which imply that they have activating and energizing effects on an organism. Second, arousal appears to result from discrepancies based on representational and generalized standards as well as from violations of ongoing-input standards. Berlyne's

(1957) findings were consistent with other examples of violations of ongoing-input standards (Davis, Buchwald, and Frankmann, 1955; Maltzman, 1967). However, in the Berlyne and McDonnell (1965) and Mandler (1964) studies, representational standards were violated with similar arousal-producing effects. In the first case, incongruous stimuli were presented simultaneously and in the second, novel stimuli were presented successively. Violations of generalized standards also appear to affect arousal as demonstrated by Berlyne (1961) and others. Haywood (1962) for example, found that a confusing message increased palmar sweating and Berlyne and Borsa (1967) obtained longer EEG's with blurred figures than with clear ones. Third, both stimulus input and expectancy factors contribute to arousal. In the overlearning and mastery conditions of the Mandler study, discrepancies were created by identical stimulus conditions. The difference in arousal was due to differences in the strength of the informational representations, i.e., in the number of trials beyond criterion. Berlyne, on the other hand, varied the collative content of the stimuli. They were more or less complete, incongruous, or symmetrical. It was assumed that all subjects were similar in that a four-legged bird or a high-uncertainty word violated their expectancies.

Data to explain why discrepancies activate the learner are not all in. However, the evidence which has been attained clearly permits the conclusions that discrepancies do activate the learner, that both the experiences and expectations contribute to arousal, and that violation of ongoing-input, representational, and generalized standards are arousal-producing.

Determinants of Discrepancy

Discrepancies can differ in their magnitude. This assertion raises the question of, "what can be done to control the magnitude of the discrepancy and thereby increase the learner's interest?" Berlyne (1960, 1965b) listed four determinants of "conceptual conflict" as follows: the number of competing responses, the relative strength of the responses, the absolute strength of the responses, and the degree of incompatability between them. Although these factors are presented in terms of Berlyne's drive-reduction model of curiosity, they can be recast into the present version of cognitive stimulation, as follows:

(a) *The number of discrepant elements*. As the number of discrepant elements increases, the magnitude of the discrepancy increases. The elements may be different parts of the stimulus pattern or facts, principles, or plans the learner has acquired. Of course, the more the learner can subsume these elements under more inclusive constructs, the less complex the learning task will be.

(b) *The probability that information regarding any one of the discrepant elements will reduce the discrepancy*. As the probability of reducing the discrepancy becomes equally distributed among the discrepant elements, the magnitude of the discrepancy increases. A study by Berlyne (1962) demonstrates the effect of both of the above factors on arousing interest. High school students were shown a quotation and a list of several possible authors. The subjects then ranked the quotations according to their interest in learning the actual authors. The number of discrepant elements was manipulated by simply varying the number of authors associated with each quotation. Equiprobability was manipulated by providing the subjects the probability that each author was the actual author. According to the present discussion, it is assumed that discrepancies would be greater when the probabilities assigned to the three "authors" were .34, .33, and .33 than when they were .77, .13, and .10, and when three authors were listed instead of two. Berlyne found that by increasing both the number and equiprobability of elements, greater self-reports of interest were obtained.

(c) The total value of the discrepant elements. Value is determined by how well the elements have been acquired and the centrality of the elements in the leaner's value-belief system. The bearded lady example, referred to earlier, is a discrepancy which gains strength from both sources. The man-beard and lady no-beard associations have been overlearned by most members of this society and thereby have acquired considerable strength. Whatever value is obtained from these associations is boosted by the implication of sex - a topic of high affective value in this society, and thereby a central element in our value system. As a result, the total value of discrepant elements is quite high.

(d) The incompatability among discrepant elements. The more incompatible the elements, the greater the discrepancy. Although incompatability of a given condition is difficult to define with precision, in general terms it refers to the extent to which one discrepant element precludes the other. Incompatability may be manifest in the meanings attached to the discrepant elements. For example, after his subjects learned the seven word, serial order list, Mandler (1964) inserted a new word and measured GSR's. If the new words were synonomous with the original word, one would expect relatively low GSR's.

On the other hand, if the interrupting word were an antonym of the original word, discrepancy would be greater and, presumably, directly related to increases in GSRs.

Differences in the logical relationships between discrepant elements may also influence their degree of incompatibility. An "either-or-but-not-both" proposition requires exclusion, while an "and-or" or an "and" proposition is less stringent. Suppose, for example, students were to report on the following topic: Andrew Jackson was either a fighter against big money interests or a symbol of the common man. In this case, the discrepant elements are similar in meaning; however, the "rules" for relating them require the exclusion of one for the other. Presumably, the magnitude of discrepancy would be relatively large. On the other hand, the topic, Andrew Jackson was a fighter against big money interests and a symbol of the common man implies little, if any, discrepancy.

The rules of relating discrepant elements and the incompatibility of their meanings appear to interact to affect the magnitude of the discrepancy, In the above example, compatible meanings (common man - fighter against big money) were linked by incompatible rules (either-or) to produce greater discrepancy than associating compatible meanings with compatible rules (and). However, consider the following topic: Andrew Jackson was either a symbol of the common man or an oppressor of blacks and Indians. In this case, incompatible meanings (common man - oppressor) are linked with either-or to result in a relatively low level discrepancy. Notice the effect of changing the either-or rule to an and rule: Andrew Jackson was a symbol of the common man and an oppressor of blacks and Indians. In the later case, discrepancy is increased by the juxtapositioning of incompatible meanings, common man and oppressor.

It has been noted that both stimulus input and expectancies contribute to the activation of the organism. We can now suggest that the amount of contribution made by each is a function of the number of elements, their equal probability or importance, their total value, and their incompatibility. Perhaps these determinants are most apparent when they are manifest in the discrepant elements of stimulus input. However, the contribution of expectancies to the size of the discrepancy is also determined on a similar basis. For example, Massialas and Cox (1966) described a lesson in which 10 short poems were presented to learners who quickly perceived their task as one of identifying the source of the poems. One poem was:

> My Thoughts turn to the Ancient Capital
>   Long life and peace during your reign
> O, Emperor.

As a result of the most salient cues, the learner may "conjure up" any number of images (i.e., of informational representations) to use as a standard. For some, the images may be of Egypt, Greece, and Rome. For others, China and Japan may also be included. Some learners may feel that the poem could just as well have been written about all five empires, while others may feel that while all are possibilities, Egypt by far is the best bet. Thus, "competing" representations become discrepant elements which vary in their number and equiprobability, and thereby affect the magnitude of discrepancy.

Optimal Size of Discrepancy

Since it is unlikely that expectations ever exactly match experiences, learners are always faced with some amount of discrepancy. However, they are not always driven to act upon them. Thus, there appears to be a threshold at which point the individual is aware of or notices the discrepancy (Berlyne, 1960). With discrepancies above the threshold, action is initiated and with discrepancies below the threshold, no action occurs. Once a discrepancy is above threshold, the relevant instructional question is: how much discrepancy is necessary to maximize learner interest?

The implication of much of what has been said so far is that increases in the magnitude of discrepancies are accompanied by greater arousal and, accordingly, increased interest in the topic of the discrepancy. Certainly common sense reminds us of the intrigue we experience with mystery and the excitement and appeal associated with surprise. Research by Berylne (1957, 1958, 1961, 1962), Davis, Buchwald, and Frankmann (1955), Mandler (1964), and others (Butler, 1953, 1954; Montgomery, 1953) is confirming in that it demonstrates that larger discrepancies are accompanied by correspondingly increased orienting reactions, self-reports of interest, exploration, or information seeking. Thus, a monotonic relationship between magnitude of discrepancy and amount of interest is implied. In applying this notion to instruction, the rule of thumb would seem to be: create as large a discrepancy as possible to maximize learner interest.

However, all increases in discrepancy do not lead to greater interest and consequent attraction. The unknown is sometimes avoided out of fear or even terror. The surprising or bizarre may shock to the point of disorientation and panic. For example, an early study found that when infants were exposed to a strange, falsetto voice, their initial reactions were cries of fear and movements suggesting displeasure (Bühler, Hetzler, & Mabel, 1927). For their part, adults initially ranked sounds with unfamiliar rhythms as unpleasant (Alpert, 1953). Hebb (1946) observed panic reactions from chimpanzees who were exposed to a sculptured chimpanzee head detached from a body or an anaesthetized infant chimpanzee. Similar reactions occurred when a familiar experimenter wore a Halloween mask. More recently, Munsinger (1964) has found a preference for meaningful (familiar) syllables to meaningless ones (unfamiliar).

Do increases in discrepancies create interest and attraction or fear and avoidance? It seems reasonable to assume that discrepancies are attractive *up to a point* beyond which they produce avoidance behavior. This suggests a curvilinear relationship between the magnitude of discrepancy and the attractiveness of the stimuli. The curvilinear relationship is made explicit or is implicit in attempts to explain motivation (Berlyne, 1960, 1963; Dember and Earl, 1957; Fiske and Maddi, 1961; Hebb, 1949; Haber, 1958; Hunt, 1963; McClelland, 1953; Munsinger and Kessen, 1964; Walker, 1964). This relationship is described in Figure 1.

The major implications to be drawn from the curve in Figure 1 are as follows: (a) Conditions characterized by little or no discrepancy between experience and expectation (bordeom) are avoided as are extreme discrepancies (panic); and (b) there is an optimal level of discrepancy which is of moderate or intermediate size. Accordingly, the contradictory responses to novelty described earlier can be construed as efforts on the part of the organism to maintain an optimal discrepancy level by avoiding extreme discrepancies (Hebb, 1946) and approaching moderate discrepancies (Butler, 1953, 1954). Other studies (Bexton, Heron, & Scott, 1954; Jones, 1966) suggest that stimulus deprivation (i.e., no discrepancy) is avoided by human subjects who attempt to increase stimulation and the level of discrepancy.

Although these studies are consistent with the optimal level hypothesis, they are not tests of that hypothesis. In fact, it is not known whether the experimenter with a Halloween mask (Hebb, 1946) created greater discrepancies for one chimpanzee than the view of a changing scene (Butler, 1954) did for another. The test, therefore, requires an experimental paradigm in which subjects respond to stimulus input which varies only along a dimension of increasing magnitude of discrepancy. This procedure assumes a technique to control the effects of extraneous factors and to calibrate discrepancies. Both of these conditions have been met with relative success in a series of experiments by Munsinger and Kessen (1964). Their results were consistent with the optimal hypothesis: moderately random words or phrases were preferred to extremely redundant or extremely random letters or words. In all, support for the optimal hypothesis seems strong enough to justify suggesting its application to instructional problems (Weatjen, 1967).

Maintaining Discrepancies

Discrepancies can be resolved in any number of ways. When the learner's instrumental responses lead to the acquisition of knowledge, the discrepancy is typically resolved in an instructionally productive fashion. New information permits the acceptance or rejection of the authenticity of the Kensington Stone or the artifacts on the Kalahari camp site may have yielded cues as to the culture of the inhabitants. However, discrepancies have a way of resolving themselves "prematurely" by a variety of mechanisms including habituation, reevaluation of beliefs, and control devices such as stop orders. Premature resolution is instructionally unproductive since instructional purposes may require continued activation or informational search. As a result, designers of instructional strategies are left with the problem of maintaining discrepancies or with what Bruner (1966) has called the pacing or sequencing of optimal levels of uncertainty.

When discrepancies are based on instructional topics which touch upon highly valued beliefs, the learner may turn to unproductive methods of resolving them in order to keep his existing beliefs intact. Accordingly, he may reevaluate one of the discrepant elements to reduce the equiprobability among them (e.g., these criticisms of George Washington couldn't have been made by a reputable source) or he may devalue some aspect of the discrepancy and thereby reduce its total value (e.g., This discussion approaches Christianity from a trivial viewpoint). Informational search may also end unproductively due to the implementation of a stop rule (Hunt, 1965; Miller, Galanter, & Pribram, 1960) which, in effect, orders the discrepancy to exit from the system. Stop rules may be set to "turn off" the learner when he has spent too much time on the topic, when the probability of resolving the discrepancy is too low, when significant others stop, or when a certain level of fatigue is reached.

Habituation to the effects of discrepancy occurs when stimuli which previously evoked a particular response are repeated to the point where the response is no longer evoked, implying that the learner is no longer aroused and the stimuli no longer attractive. The effect of habituation is to resolve the discrepancy, typically with a loss of attention to the instructional task. Sharpless and Jasper (1956) inserted electrodes into their cat subjects and then delivered loud sounds which lasted three seconds. Although the initial bursts evoked EEG reactions associated with high arousal, after 30 trials the arousal reaction had all but disappeared. When the experiment was repeated on successive days, the orienting reaction "recovered," but with each day habituation was more rapid. Davis, Buchwald, and Frankmann (1955) found similar evidence of habituation in human subjects on some, but not all measures of the orientation reaction. In both studies habituation was in response to violations of ongoing- input standards. Learners also appear to adjust to discrepancies based on representational or generalized standards. Kubis (1948) repeatedly presented subjects with a light, a buzzer(ongoing-input standards), and a question (representational or generalized standards). Habituation occurred to all three types of stimuli, although habituation to the question was the slowest.

Since the stimuli remain constant in habituation studies, the weakening of the orienting response implies that the expectations change to match the current stimulus input, and thereby reduce the magnitude of the discrepancy. If this were the case, one would expect first avoidance then approach responses and, finally, indifference as the magnitude of discrepancy becomes smaller with repeated presentations of unfamiliar stimuli. This prediction is based on tracing the curve in Fig. 2-1 along the abscissa from extreme discrepancy to no discrepancy. In the Alpert (1953) study, an unfamiliar rhythm was repeated many times.

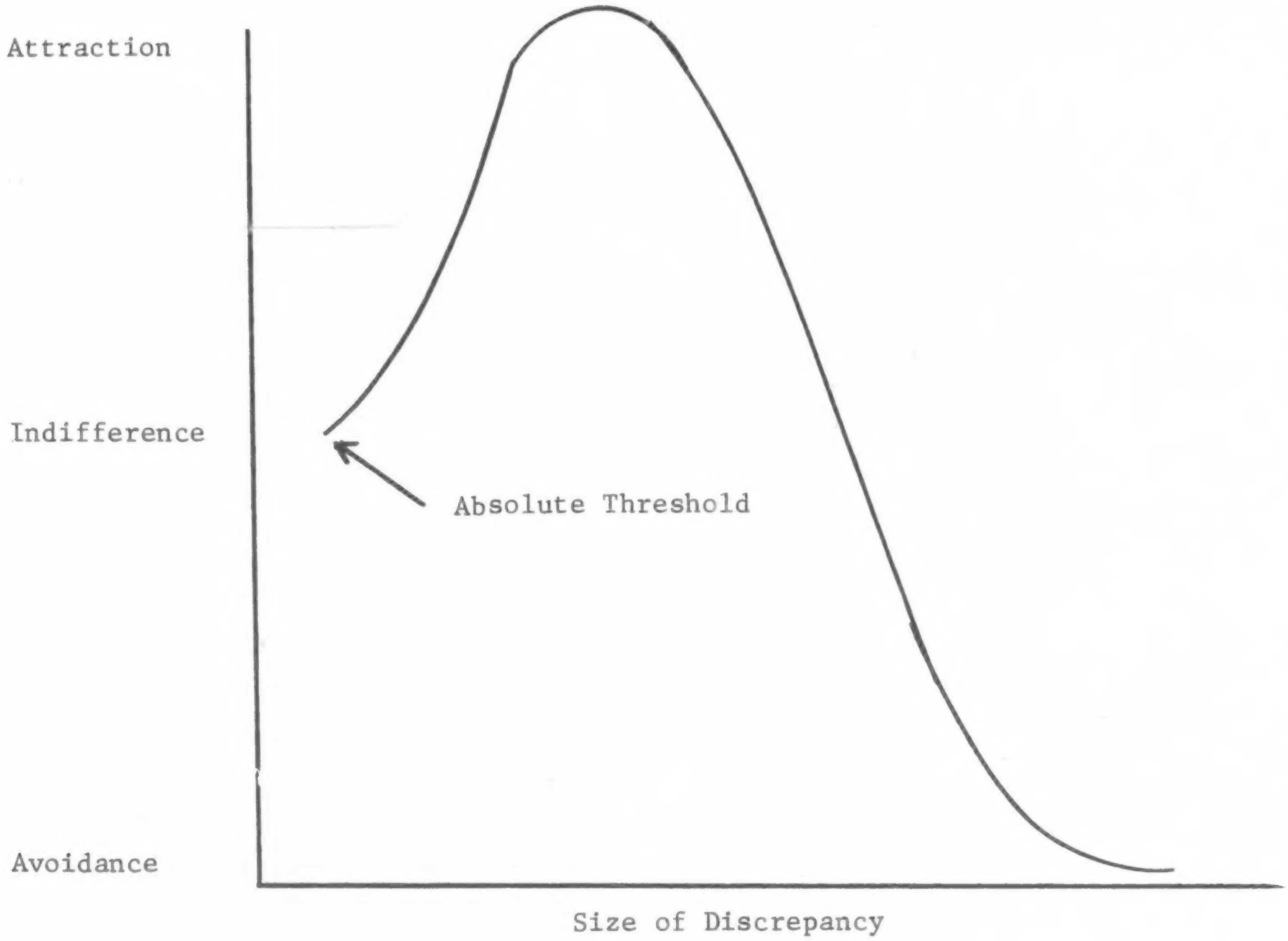

Fig. 2-1. Interest of Attraction as a function of Size of Discrepancy. (After Berlyne, 1960. The Abscissa has been changed from stimulus intensity to size of discrepancy.)

On first hearing, it was rated as unpleasant. With repetitions, the rhythm was considered more pleasant until finally, after an extended period of exposure, the subjects became indifferent toward it. A similar trend from fear to interest in a strange stimuli (a falsetto voice) was observed in infants by Büehler, Hetzler, and Mabel (1927) when the input was repeated.

The fluctuation or modification of the standard suggests that expectancies are not set at an absolute level of stimulation, but rather at the level of stimulation to which the learner is currently adapted. Accordingly, discrepancy can now be defined as the difference between the adaptation level and the input (McClelland, 1953). One instructional implication of variable standards is that the instructor can not maintain an optimal or intermediate level of discrepancy for an extended period without losing student interest. With repetition, habituation may occur even to the "dynamic" lecturer (such as the experimenter in the Coats and Smidchens study) if he follows the same pattern of behavior. Or, for example, the repeated use of questions minimizes their motivational effects. In this regard, educational practice may be working against the activation of the learner. Gall (1970) reported that teachers average approximately 350 questions a day.

A second implication of variable standards is that the instructor must continually increase the magnitude of discrepancies in moderately sized steps to avoid the effects of habituation. This implication is obviously untenable. If applied, lecturers would have to increase the animation of their delivery until it reached a feverish pitch. Fortunately, for lecturers and listeners, alternatives to constant increases in the magnitude of discrepancy exist. Sharpless and Jasper

(1956) found that after habituation, a change in any characteristic of the stimulus restored the orienting reaction in cats. These changes included both increases and decreases in the loudness of the stimuli. Similar results were obtained by Haber (1958) with human subjects. He hypothesized that moderate changes in either direction from the adaptation level would be regarded as pleasing, as is graphically presented in Fig. 2-2. This graph is a mirror-image of Figure 1 with the adaptation level (AL) added as the standard for the discrepancy. Haber obtained results which directly paralleled this theoretical curve and were consistent with those of Munsinger and Kessen (1964) who found moderate discrepancies were preferred to extreme or no discrepancy conditions. The Haber study also demonstrates that intermediate discrepancies in either direction are attractive and that the point of comparison for new input is the adaptation level.

Recently, Silvestro (1970) also demonstrated that both increases and decreases in discrepancies can be attractive depending on the subjects' immediate prior experience. Silvestro used written material and tasks that were comparable to those used in instructional settings. The subjects were first "saturated" with either a convergent or divergent task. The convergent task typically required the subjects' dominant response and therefore represented little if any deviation from his representational standard. Divergent tasks, on the other hand, usually involved violations of generalized standards. For example, one convergent satiation task was a crossword puzzle with items such as "Abbreviation of Pennsylvania." The corresponding divergent task was the construction of a crossword puzzle. After a satiation period (during which time habituation presumably occurred), subjects were shown

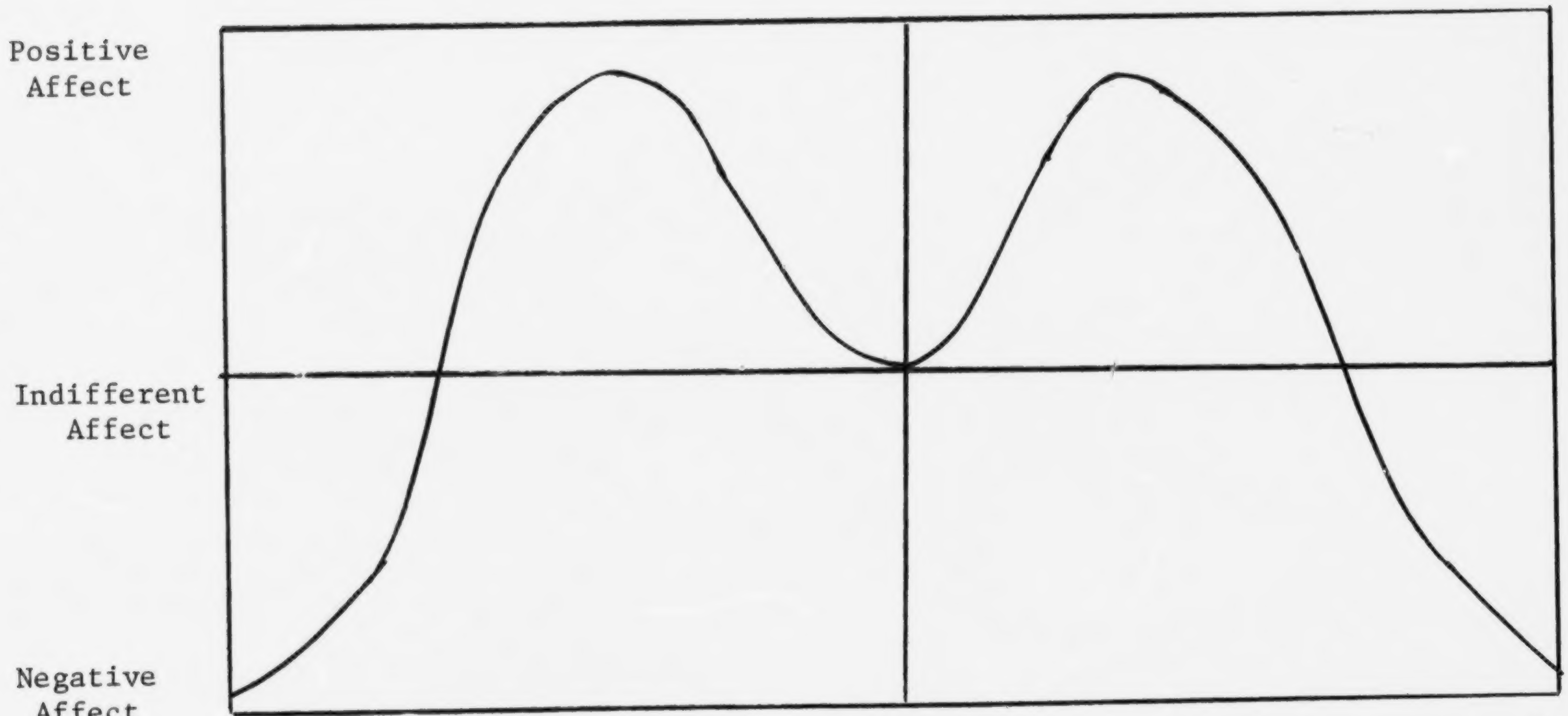

Fig. 2-2. Affect as a Function of Discrepancies above and below the AL. (After Haber, 1958.)

slides each of which contained a noun and a non-noun and were instructed to select one. For some subjects, nouns were arbitrarily chosen as correct responses and for others non-nouns were chosen. Feedback consisted of a novel association of the word for correct responses and a common association for incorrect responses.

As a result of convergent satiation (i.e., with adaptation level at low magnitudes of discrepancy), novel associations were sought while divergent saturation (i.e., adaptation level at high magnitude of discrepancy) resulted in seeking non-novel or familiar conditions. The Silvestro study suggests that habituation occurs to both high and low magnitudes of discrepancy, with the effect of according discrepancies of differing magnitudes incentive value. The findings also imply that, in this case at least, habituation is generalized across somewhat different stimuli whose only common feature is their novelty. It may be recalled that Sharpless and Jasper (1956) found habituation to violations of ongoing-input standards to be quite specific. Exactly under what kinds of conditions habituation is specific or general remains a problem to be explored.

Some instructional approaches maintain discrepancies by providing the learner with data which are instructionally purposeful and which allow him to seek and maintain his own optimal level of discrepancy. Dithering techniques, discovery or inquiry methods, responsive learning environments, and Montesorri techniques are examples of devices in which the learner may regulate the amount of discrepancy he encounters. For most instructors, prevention of habituation and maintenance of discrepancies require building varying amounts of discrepancy into their instructional strategies, and thereby maintaining control over the size of the discrepancy. In this case, strategies to mitigate the effects of habituation include (1) supplying information periodically during the course of a problem to lower the level of an initially large discrepancy, (2) providing a sequence of sub-problems to rekindle the discrepancy when it threatens to be unproductively resolved, and (3) using "pursuit" questions (Ribble and Schultz, 1970) which confront the learner with the logical inconsistencies of his position or with contradictory evidence.

The Kalahari camp site lesson illustrates how discrepancies can be renewed by techniques which bring the learner closer to the resolution of the discrepancy but do not resolve it. If the learners were given only the camp site map with instructions to describe the way of life of the inhabitants, after some effort they may evoke the stop rule that the probability of resolution was too low to merit continuation. However, after considering the initial data, learners are shown slides of the immediately surrounding environment of the site and given a "site report" containing a factual description of the area and then asked to return to the original problem. At other points in the four-day lesson students are asked questions which initiate a constellation of "mini-discrepancies" whose resolution will assist in attaining resolution of the major discrepancy. How old is the camp site? Why did people choose this spot? How long was it occupied? How are the people organized? In the description of this illustrative lesson, the teacher also maintained discrepancies in her dialogue with learners. When a student observed that the camp site "can't be too old or it would be buried," a statement implying resolution of the age-of-the-site discrepancy, the instructor replied that the camp site may be on a mountain top or uncovered by winds and shifting sand.

Discrepancies and Individual Differences

There are many motivational, personality , and cognitive variables which predispose the learner to make idiosyncratic responses to discrepancies. This discussion will focus on several which appear to be most directly associated with violations of each type of expectancy. First of all, individuals differ in the level of arousal (measured by GSR) they experience from violations of ongoing-input standards (Maltzman, 1967). These differences which were obtained at the outset of the experiment, were found to persist throughout the conditioning and extinction phases. One implication of these differences is that the more highly aroused or attentive individual is better able to make discriminations. Lynn (1966) reported research by Soviet psychologists (Voronin, Sokolov, and Bao- Khua, 1959) to the effect that individuals also differ in their rate of habituation to violations of the ongoing-input standard. Subjects who habituated quickly to repeated presentations of an auditory stimulus, tended to "under-react" to a subsequent problem in contrast to those who were slow to habituate. In regard to instructional implications, these findings are suggestive at best; they imply that variety in presentation is particularly important to maintain attention with the consequent task involvement for learners with rapid habituation rates.

It has already been noted that input which contradicts an individuals' existing representations is a rich source of information. However, some persons may not expose themselves to information which violates their representations and, therefore, are less effective in their efforts to productively resolve discrepancies. The highly dogmatic learner presumably rejects new belief systems because of the threat such individuals associate with beliefs which differ from their existing cognitive systems. They, more than others, would avoid discrepant or novel information. On the other hand, low dogmatic learners experience no such threat and would, accordingly, be open to novel information (Rokeach, 1960). However, research in this area is inconsistent. High dogmatics made more errors than low dogmatics in learning "belief incongruent" associates (e.g., ball-square) but excelled in the acquisition of "belief congruent" pairs such as ball-round (Adams and Vidulich, 1962). Kleck and Wheaton (1967) found that high dogmatics recalled less information which disagreed with their existing beliefs (i.e., with their representation) than low dogmatics and placed higher evaluation on congruent information. On the other hand, Smith (1968) found that only when subjects had little interest in the experimental topic was a negative relationship between dogmatism and knowledge of discrepant facts obtained. More recently, others (Hamilton, 1969, Feather, 1969, Schultz, 1970) failed to obtain a relationship between dogmatism and the search for and recall of discrepant information.

Intolerance of ambiguity is a tendency to view ambiguous situations as threatening while tolerance of ambiguity is a tendency to view such situations as desirable (Budner, 1962). Since violations of representational standards can be assumed to be an ambiguous condition, learners who are intolerant of ambiguity would be expected to avoid information which suggests a discrepancy exists or which may add to the magnitude of the discrepancy while those who are tolerant of ambiguity are assumed to seek such information. There is little direct evidence to bear on this assumption. Feather (1964) found that the more intolerant of ambiguity the subject was, the stronger was his tendency to judge congruent arguments as correct even when those arguments were invalid. Schultz (1970) obtained a reliable negative relationship ($\underline{r} = -.42$) between acquisition of discrepant information and intolerance of ambiguity.

Remediation appears possible, at least in directing high dogmatics toward unfamiliar information. Ausubel and Tenzer (1970) found that dogmatism impaired the learning of a pro-Hanoi passage on the Vietnam War. However, these effects were "neutralized" by an introduction which suggested that (a) "intelligent and fair-minded persons" do not reject opposing viewpoints out of hand, and that (b) even "familiar history" is never purely objective, but reflects the biases of the historian. Thus, for high dogmatics, instruction should include an introduction which cautions learners to be open-minded and to realize that even authorities are influenced by their own biases.

A number of studies have been conducted which examined variables affecting pre-decision information processing (Salomon, 1968; Sieber and Lanzetta, 1964, 1966). Usually in these studies, the subject is presented with an indistinct or unstructured stimulus pattern with instructions to identify it. Thus, the experimental paradigm centers on the violation of a generalized standard and is designed to study the individual's efforts to resolve the ensuing discrepancy.

One factor which appears to influence information processing is the "structural complexity" of the individual's cognitive system (Sieber and Lanzetta, 1964). Sieber and Lanzetta (1966) later examined the effects of individual differences in cognitive complexity (i.e., of "structurally simple" and "structurally complex" individuals) and of two training procedures on pre-decision information processes. One training procedure (uncertainty training) was designed to facilitate the generation of response alternatives, or in the context of the present discussion, of alternate representations. This was accomplished by presenting the subject with an ambiguous stimulus and asking him to generate 10 guesses as to its identity. The subject was encouraged to make unusual guesses and was rewarded for novel responses. The purpose of this training procedure was to increase the number and equiprobability of representations the subject "brings to" any given situation. In the second training procedure (mediation training), subjects were shown slides exposed for 1/100 of a second and were asked to report as many details as they could to the experimenter and then to guess what was on the slide. The purpose of this procedure was to develop skill in differentiating and encoding information. A control group received neither training procedure.

After training, the subjects were given the task of identifying objects on tachistoscopically exposed slides which the subjects presented to themselves. Measures were obtained of the number of exposures before decision, the time of each exposure, the correctness of the decision, and the additional, relevant information given with the decision.

When no attempt was made to influence the subject's decision-making process, structurally complex subjects generated more alternative responses and made greater differentiating, encoding, and inferring responses than structurally simple subjects. The general effect of both training procedures was to increase the complexity of information processing by increasing the amount of information search, the amount of information subjects provided with the answers, and the amount of correct answers. In particular, uncertainty and mediation training had little effect on the amount of information search of structurally complex subjects; however, the effect of training was to increase information seeking of structurally simple subjects to the point where it equalled that of their more complex counterparts.

The training procedures used by Sieber and Lanzetta can be applied to instructional settings with little modification. Sieber (1969) elaborated upon these procedures by developing a remedial program to generate uncertainty in students who "know it all," in "true believers" who reject non-supportive information, and in others who unquestioningly accept what they read or hear. The program consists of the following: (a) presenting learners with problematic situations and explicitly directing them to generate alternate hypotheses, to estimate the amount of uncertainty they associate with each hypothesis, and to search for relevant information to support the hypotheses, and (b) rewarding the reasonableness of the learner's uncertainty estimates and their discrimination of problem cues which lead to opposing solution alternatives rather than rewarding the attainment of correct answers.

Summary

Cognitive stimulation was described as a system of intrinsic motivation in which the discrepancy between input and expectation is an essential feature. Once begun, stimulation continues until the discrepancy is resolved in either a productive or unproductive fashion. This formulation of cognitive stimulation has relied heavily upon psychological theory and research. There is no parallel instructional theory of intrinsic motivation which has been tested for its application to classroom conditions. Nevertheless, the notion of cognitive stimulation as described in this chapter suggests questions which the instructional decision-maker may consider to maximize learner interest.

(1) Do the instructional materials contain collative content? The instructor should highlight the complexity or the novelty of the learning materials. Surface complexity may lead to increased interest in perceptual tasks such as letter recognition. In contrast, potential complexity may foster interest in more academic matters which require the acquisition or transformation of knowledge. When appropriate, the subject matter content should be selected for its absolute novelty, or more likely, because it provides a new context for a familiar idea.

(2) How are expectations violated? Ongoing-input standards are violated by variability in factors such as teaching style, mode of presentation, duration of instruction, and the learner's physical position with the effect of maintaining or heightening attention. Representations should be violated by supplying information which contradicts the learner's beliefs and thereby directs him toward the new or discrepant position. When information is withheld due to an instructional communication which is confusing, ambiguous or incomplete, generalized standards are violated with the effect of initiating a general inspection of the instructional topic.

(3) How are the motivational effects of discrepancies maintained? The instructor should avoid content in which discrepancies are extremely large or not apparent at all to the learner. Once a discrepancy of intermediate size is created, the instructor must increase or decrease its magnitude in moderate amounts to prevent habituation. By providing

new information and posing sub-problems, the instructor may affect the number of discrepant elements, their equiprobability, total strength, and incompatability and thereby regulate the size of the discrepancy.

(4) How can instruction be adjusted to individual differences? The form and content of instruction must be shifted more frequently for learners who habituate to discrepancies rapidly or who experience relatively low levels of arousal from them. The dogmatic learner should be cautioned to look at new viewpoints before examining controversial materials and the structurally simple learner must be trained to generate hypotheses and to encode information if he is to benefit from the motivation associated with discovery or inquiry strategies.

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Chapter Three

Strategies for Orienting Students to Educational Objectives

Nicholas M. Sanders

The motivated and attentive student may listen to a classroom presentation and study the lesson diligently, and nevertheless not perform well on a lesson test, if his or her academic endeavors are irrelevant to the goals of the lesson. Teachers and textbook authors are aware of this possibility and generally attempt through various means to orient students to the intended learning outcomes of the lesson. Statements of purpose and objectives are sometimes presented prior to consideration of the lesson. Often, also, essential points are highlighted in the course of lecture or reading assignments. Other methods used involve careful phrasing of assignments to direct learners and/or specification of the type of test to be given on the lesson.

The implicit assumption underlying these procedures is that the student is an active learner: if the student understands the intended outcome, his or her overt and covert educational endeavors can be self-directed to attaining that outcome. In the absense of such knowledge, the learner is assumed to adopt an orientation contingent on past experiences in similar situations and/or preferences, which may or may not be appropriate for the outcomes the teacher expects.

This view of learning in formal educational settings implies that the student is always somewhat engaged in problem-solving. The problem is how to used the subject matter. Some examples of these choices involved are: "What are main points versus merely illustrative points?" "Should one memorize or seek to develop applications?" The answers to these questions involve choices of processes to be used in studying. The choices may or may not be consciously considered and decisions made may change in the course of studying - as new information from the teacher or text is available. But the most important factor influencing the decisions is the student's goal orientation.

As mentioned previously, the student can be assumed to have some goal orientation whenever he or she is involved in attending to classroom presentations or studying outside class. The primary issue considered in this chapter is the extent to which a teacher can influence the student's goal orientations through various procedures

Prior Statement of Objectives

Does explicit statement of objectives prior to a lesson facilitate lesson learning? The most direct method by which a teacher is assumed to have an orienting effect on the students' learning is through explicit statement of the desired outcome of a lesson immediately prior to the presentation of the lesson. Though the teacher may have reservations concerning the use of highly specified objectives (see Popham, 1969, for a review of some reservations), the focus of this section shall be on the very essential question of whether presenting the objectives to students really does help them to attain the stated objective.

Several rationales may be given for why such prior information should aid the student (Gagne, 1970, pp. 306-7). Initial statement of objectives may provide direction for the learner: the objectives may establish a set that the learner uses to reject the extraneous and irrelevant aspects of the lesson, focusing more complete attention on the relevant essential aspects. Another possibility is that knowing the objectives enables the learner to match his or her own interpretation of the subject matter with that in the objectives, and thus have immediate feedback as to the appropriateness of the interpretation being made. Of course, both set and immediate feedback may operate together to facilitate learning.

While the rationales offered may be convincing, it is still quite essential to ask whether learning is actually improved when the learner is aware of the purpose of the lesson. Surprisingly, the only rigorous study of this question implies that students who are informed of the desired outcomes of a lesson do not possess more of these outcomes when tested than do students who are not informed (Jenkins & Deno, 1971). The results were the same whether the objectives stated were in general or specific (i.e., behavioral) form, and whether the unit was read by the students or given by a teacher in a lecture.

Of course, no one study is sufficient to establish the value or lack of value of any technique. Limitations of the conclusions may arise from the specifics of the study - e.g., age and other characteristics of the students, nature of the subject matter, size of lesson and time spent on the lesson, and the time elapsing between studying and being tested. Among the possibly limiting characteristics of the study mentioned above are: (1) Only college students were involved as learners. (2) The lesson was on the methods used in the social sciences and was well-structured, highlighting the points essential to the objectives. (3) Students were given 1-3/4 hours of exposure to the lesson. And (4) the test was administered immediately after the study period. Unfortunately, at this time one cannot state whether these specific characteristics are indeed limitations to the findings obtained by Jenkins & Deno (1971), since there is a paucity of sound empirical studies addressing this specific topic.

However, some research in the closely related area of providing questions to students prior to study does throw additional light on the issues mentioned above. In one study (Peeck, 1970), in which college students were given 15 to 20 minutes to study a 3,000 word passage on Greece, the students who were provided prequestions did retain more of the relevant material over a one-week period, though, as in the Jenkins and Deno study, they were not superior on a test immediately after the study period. These results suggest that prior knowledge of the lesson objectives may help the learner in the long run, even though they do not seem to be effective initially.

An additional, and very important, point to be gained form Peeck's research on prequestions is the lessened attention the student has for aspects of the lesson not specified by the prequestions. Often those students who did not have prequestions learn other, incidental aspects of the material more thoroughly than those who have the prequestions. This outcome suggests that prior knowledge of objectives may be directive to the point of causing the learner to disregard those aspects of the lesson that do not seem to be directly relevant to the objectives.

In summary, the two studies directly relatable to the issue of effectiveness of telling the student the objectives of a lesson he or she is to study indicate that no immediate benefit is gained in doing so, though evidence exists from one study that there may be a longer term memory benefit. The teacher should also be forewarned that subject matter not clearly related to the objectives presented probably will be learned less well than if no objectives had been stated! But it should be noted that these conclusions are far from definitive. The studies cited have not been replicated. In addition, there is no relevant research yet with children of school age, and no large scale units of lessons have been used in the research cited.

Questions Within the Lesson

Are students' goal orientations influenced by questions interspersed in subject matter? The use of questions interspersed during a lesson can be seen as serving at least two purposes. First, questions may be used to especially emphasize particular points. The intent is to intensify attention to specific critical points. This function is basically a directive one, intended to lead the learner to more intentional learning of the answer to the question. The second function is a more general one: interspersed questions are seen as leading to a general arousal of interest in the material being presented. If the second function is realized, the learners having the questions would be expected to learn not only the answers to the particular questions asked (intentional learning), but also more of the material about which no questions were asked (incidental learning). The purpose of this section is to provide information on both functions of questions, the specific directive one and the more general, lesson-orienting one.

Research related to the effects of questioning as the lesson proceeds has been much more thorough than that on the effects of prior statement of objectives, which was covered in the preceding section. The studies have, however, been carried out solely with adult learners, and have usually involved learning from reading. Major problems studied in the available research deal with the location of the question in relation to the relevant material, the spacing of questions throughout the lesson, and the type of question.

When questions are interspersed in a reading assignment - whether they come before or after the question-relevant material, the directive (intentional learning) function of questioning has been validated: students learn more of the question-relevant material. But the students who have questions before the question-relevant material sometimes do not learn as much of the remaining aspects of the lesson (incidental learning) as the students who have no question in their reading lesson (Frase, Patrick, & Schumer, 1970; Rothkopf & Bisbicos, 1967). One of the most interesting and consistent findings in these studies is that questions that come *after* the question-relevant materials lead to a better overall learning of the reading assignment than questions placed before the relevant materials (see Frase, 1970, for a more complete review of such studies). These results were obtained even though the students were not allowed to review the relevant materials, and in most of the studies no answers to the questions were provided. While questions placed after the relevant material might seem to serve merely to repeat material for review, research by Bruning (1968) indicates the question form of the review is important. He found that a question-type review of materials is more effective than a statement-type review. Now without looking back, answer the question: "Where should one place questions in relation to the question-relevant material, in order to facilitate overall learning?"

One study (Di Vesta & Gray, 1971) that has been done with a lecture presentation, rather than a reading assignment, revealed that the use of questions after short 5-minute lectures, but well before testing, produces greater retention of the lecture material than no use of questions. Also, Berliner (1970) found that questions interspersed in a 45-minute lecture resulted in better recall than that exhibited by students allowed to take notes. Thus, there is some support for generalizing the findings obtained in studies involving learning from reading to the area of learning from listening.

Of course, the spacing of the questions is important. Putting the questions closer to the question-relevant material seems to be best for use of post-questions, but the interfering effect of pre-questions on incidental learning is greatest when questions are close to the relevant materials (Frase, 1967, 1968; Rothkopf, 1966). It should be noted here, however, that these studies never interspersed questions more often than every ten sentences, and thus it is possible that placing questions very close to the relevant material may lead to a significant disruption of overall learning as Ausubel (1963) has asserted.

The type of post-question asked may also be an important factor in the extent to which questions may facilitate student learning. Post-questions that clearly imply classes of information to be learned seem to exert a greater positive influence on learning than those that do not. For example, Rothkopf & Bisbicos (1967) found that post-questions dealing with technical terms, names of people and places, and numerical values (dates, spatial or temportal dimensions, and quantities) led to greater subject matter acquisition than did questions having to do with "common" non-technical, descriptive words (e.g., "red" and "bottle-nosed").

This finding should not pose great difficulty in instructional application, for many educational objectives do indeed entail the learner's acquisition of names, technical terms, or numerical values.

The educator involved in producing reading assignments should find much of value in the studies mentioned in this section: Intersperse questions in the chapter or article. Write the questions to refer to the major points or objectives of the lesson, and place them only shortly after the relevant material has been presented. These points are well supported by research with adult learners. While there seems to be no reason to assume different results for children and adolescents, definitive empirical support is lacking at present.

For the educator who is involved primarily in classroom presentations, the research presented is less definitive. Two studies have laid the groundwork for extension of the points about questions in reading assignments to lectures. However, here also the conclusions are based solely on research with adults.

Directive Effects of Assignments

Do assignments affect students orientations to the objectives? At the core of formal education is the notion that the tasks assigned to students will direct the students to engage in particular overt and mental activities, and, therefore, should lead to relatively specifiable learning outcomes. Some assignments (e.g., "Work the problems on page 200 of your workbook.") are more specific than others (e.g., "Write a term paper on some economic problem our country faces."). Always, however, the intent of the assignment is to involve the student in a task that will develop specifiable new skills and knowledge or exercise specifiable previously learned skills and knowledge Do assignments lead to these intended ends?

Of course, the answer to this question might be quite different for some assignments than for others. Since many studies would be required for a more complete answer to the question - and since there is very little research available, this section shall be devoted to the specification of points about research on the topic. These points can most profitably be discussed in the context of one study that directly focuses on the effects of different classroom assignments.

Hackman (1970) found that she was able to predict particular characteristics of essays, contingent upon the essay assignment the students were given. Using a two week high school unit on propaganda analysis, the students were given one of three assignments: (1) Production, e.g., "Describe a tour of an imagined propaganda museum filled with superb pieces of propaganda." (2) Evaluation, e.g., "Analyze whether commercial propaganda (advertising) has created unhappiness and unrest among the poor of our country." (3) Problem-solving, e.g., "Outline plans for advertising a high school dance in detail." Essays were objectively rated on five characteristics: (1) suggestion of a course of action, (2) ideas and/or the mode of presentation were unusual, (3) optimism of point of view or general tone, (4) grammatical, rhetorical, and literary qualities, and (5) involvement in the issue, signified by the adoption of a point of view. The production assignment essays were more original than the others, but were less action oriented and less issue involved. The evaluation assignment essays, in contrast, were more issue involved, though the rated quality of presentation and originality were considerably less than the essays written for the other two types of assignments. Finally, the problem-solving essays led to the most pronounced action orientation and optimistic viewpoints.

While this study by Hackman obviously cannot be used as a paradigm for answering all questions concerning the effects of differing assignments, there are several valuable general points that emerge from a consideration of it. First, the three assignments were compared not on the basis of one characteristic (such as knowledge about propaganda), but instead were scored for several characteristics, which had been developed prior to the empirical study as different predicted outcomes of the different assignments. Thus, Hackman's research was able to reveal what is probably often the case but hardly ever investigated in educational research: no one procedure is optimum for all the possible objectives inherent in learning about a particular subject matter topic.

The second point is closely related to the first, but in contrast to the first, it is a short-coming of Hackman's study. In demonstrating the different outcomes of the three assignments, she rated the students on different assignments. To provide more definite conclusions concerning the learning outcomes of skills, attitudes and knowledge each assignment generated, information from a set of measures that is the same for all students should follow the assignments. That is, we would not be able to say, from the results of the study, that the production assignment students were more original but less issue-involved concerning the topic of propaganda analysis than the other students as a result of the assignment. In order to make that claim, supporting evidence from an assignment that was common to all students and less directive in nature (such as: "Discuss the use of propaganda.") would be required. The students had been told to engage in different activities.

They did engage in different activities. We do not know whether they acquired different skills, knowledge and attitudes.

The final point to be made here concerning the effects of different assignments pertains to the specificity of the assignments. Hackman's assignments were at an intermediate level on the specificity-generality dimension. The teacher most likely will find that the more general the assignment he or she gives, the less influence that teacher will have on the learning outcomes. A very general assignment (such as: "Study chapter 10 for next week.") probably will result in different students learning different things. Sanders and Tzeng (1971b), for example, have found that some learners tend to learn rotely while others will seek to discover conceptual interrelationships when the assignment instructions are very general.

Types of Tests

Do the teacher's testing practices influence lesson goal orientations? Most teachers would like to believe that various aspects of their testing procedures serve to facilitate and direct learners in the attainment of educational objectives. These hopes are that testing serves educational, as well as evaluational ends. Using essay exams instead of objective types is one example of a testing procedure for which educational benefits are deemed to accrue. In this section the focus shall be on reviews of research and issues involved in this area.

Students report that they prepare differently for objective tests and essay tests. Studies by a number of investigators indicate college students say they attempt to master smaller units of information when they anticipate an objective test and larger units when preparing for an essay exam (c.f., Meyer, 1935; Silvey, 1951). Because the mastery of larger units is often seen as the more appropriate educational goal and because mastery of the larger unit would seem to imply learning of smaller unit components, some authors of texts on testing have advised teachers to make greater use of essay type examinations (Ahmann & Glock, 1971, p. 179; Gronlund, 1965, pp. 180 and 184-5).

However, the empirical evidence from research in classroom settings has not convincingly revealed actual learning outcome differences for different testing procedures. These studies have usually indicated that there are no differences in scores on any type or combination of types of exams among student who were led to expect the different types of tests (e.g., Hakstian, 1971). Even in more controlled laboratory settings the expected differences in learning outcomes have not often been manifest (Hakstian, 1971; Meyer, 1934; Weener, 1971).

There is one set of studies, however, that suggests methods used in previous studies (and those usually used in the classroom) have not provided for a clear-cut investigation of the educational potential in utilizing different types of tests. Sanders and Tzeng (1971a), in accordance with past rationales given for essay versus objective examinations, reasoned that a student who expects to be tested with questions requiring knowledge of interrelationships of the specifics of a lesson (e.g., the sequence of points in a development of a mathematical proof) will actually learn more interrelationships, but fewer specifics than the student who expects questions on the specifics alone. These predictions, which received some support in their two studies, place the emphasis upon the type of question (specifics versus interrelationships) instead of upon the more traditional distinctions of types of tests (essay versus objective). These authors go on to point out that the previous research had not revealed these differences probably because the procedure used to score the essay examinations had focused upon specifics, in an effort to produce more reliable scores, and/or because the objective tests included questions of both specific and interrelationship natures.

The implication of Sanders and Tzeng's work for the teacher are that in many cases the student's expectation for test questions of specific or interrelationship nature do affect the learning outcome. In addition, there seems to be a tendency for the learning of one type to interfere with the learning of the other type. Thus, the earlier assumption that higher level learning leads to greater mastery of specifics may not be valid, and the teacher should realize that greater emphasis on interrelationships may lead the student to learn fewer specific points.

Summary

What do we know about the teacher's directive influence on the student's orientation to educational objectives? Four general ways in which the teacher is often assumed to exert a directive influence on students' orientation to educational objectives have been considered. The results often have not confirmed the expectations. Must surprising is the indication that actually telling the student the expected outcome is not a very potent way to facilitate his or her attainment of that otucome. In fact the best way to fully direct the student to overall mastery seems to involve a continual focusing of the student on the lesson by interspersing questions shortly after the question-relevant material has been presented.

Among the less direct ways in which a teacher might influence the goal orientations and learning outcomes of students, the most obvious one - the classroom assignment - has received so little empirical investigation that only prescriptions for additional research were offered. The directive effects of using certain types of tests has not received empirical support, though there is some support for saying that specific versus interrelational nature of questions - whether in essay or objective test form - may lead to predictably different learning outcomes.

Though the two preceding paragraphs do serve to summarize the results of the research reviewed in this chapter, the reader should realize that there are huge gaps in our knowledge on these topics. For topics so central to the educational enterprise, there seems to have been relatively little involvement in providing rigorously designed studies of the issues. For this reason, each section has included suggestions for increasing our knowledge of the teacher's influence on students' academic goal orientations.

Theoretical Speculation

Though it is certainly too early to attempt conclusions in this area, it may not be too early to speculate about the primary factors influencing goal orientations and their relationships to learning outcomes. A student may be expected to have many skills and much knowledge gained from previous experiences. Various aspects of these resources can be brought into use in acquiring new skills and knowledge. Major classifications of the types of influence the past may have on mastery of the task at hand are discussed at length in the following chapter of this report. Briefly summarized, these classifications are:

Type I Transformations - All skills relevant to verbatim learning are involved. The student may bring to bear mnemonic devices and other elaborate schemes, though the goal is a memory of specifics. Type II Transformations - The emphasis is on grouping specifics, by abstracting common characteristics and by defining interrelationships. Also, these transformations provide for the generation of unpresented specifics through application of the abstracted characteristics and features of the interrelationships. Type III Transformations - This type of transformation results in a novel but appropriate organization or implication of some aspects of the subject matter.

Using the above transformation types, one may broadly classify goal orientations as having similar characteristics. That is, the students' goal orientation may entail the use of Type I, Type II or Type III transformations. Most likely, in the absence of other directions, the student will assume the goal entails a Type I transformation, though he or she may be incorrect as to which specifics are going to be most important. If the teacher, through interspersed questions, focuses on particular specifics, the student will direct his or her attention more fully on those specifics as well as being assured that the Type I transformations are the important ones. Unfortunately, a prior statement of objectives may not be sufficiently directive, since the relevant specifics are not readily locatable in the lesson.

Type II goal orientations are probably susceptible to the same influences as Type I, though they are most likely not as readily assumed in the absence of external (e.g., teacher's) direction. If, however, it is well-known among students that test questions will stress this type of transformation, the students may adopt Type II goal orientations for that course.

From Hackman's (1970) study of essay assignments, one can speculate that Type III goal orientations probably are called forth in a different way from either of the other types, through more general indications by the teacher that flights of the imagination are appropriate.

All the immediately preceding discussion must be viewed as purely speculative at this time. Hopefully, however, it will serve as heuristic to further research in this important area of educational concern.

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Chapter Four

Instructional Strategies and Learner Transformations

Francis J. Di Vesta

In this chapter, summarized in Table 1, instructional strategies are described in terms of cognitive constructs. The concern is with the means by which external stimuli, whatever their "real" characteristics, manage to be processed and transformed into ideas that can be retained by the learner for indefinite periods of time and then can be retrieved. Some unique features of these transformations are that, a) the nature of what is stored or retrieved can be controlled to some extent by an external agent such as the instructor; b) what is retrieved can be retrieved in a form that may be identical to what was stored but more often than not it is retrieved in novel ways ... sometimes deliberately and often not so deliberately by the learner; and c) that transformations are clearly influenced by previous learning.

In an article entitled "The Four R's of Remembering" Pribram (1967) emphasized the importance of transformational processes as follows:

"Instruction (shared discovery of structure) should supplement teaching (showing). The tools for structuring and restructuring must be developed by the [student]. The machinery of reconstruction must be put together. The techniques of analysis and synthesis are to be emphasized. The simple repetition of loosely connected facts ought to give way to the search for structure in the material to which the student is exposed" (pp. 17 and 18).

Table 1

Descriptors, Teacher-Student Activities and Individual Differences (ID's)

Related to Learning and Remembering Each Kind of Transformation

Descriptors	ID's	Teacher	Student	Remembering & Forgetting
Type I Transformations: Associational				
Non-reductive Restricted Codes Associations Copying Verbatim Learning Traces	Rote Learning Ability Digit Span	Provides Practice Uses highly specific objectives Employs motivated repetition Encourages use of mnemonic aids Reduces interference by isolating(blocking) material Tests by verbatim true-false or multiple-choice recognition or recall	Rehearses or memorizes Learns in verbatim form Uses arbitrary associations Makes associations based on contiguous occurrence of two events	Primarily a function of conditions during learning Interference due to proactive or retroactive inhibition Amount of rehearsal, distribution of practice important Spontaneous, random fluctuations in the activity state of elementary associations changes in stimulus context
Type II Transformations: Conceptual				
Mediators Abstract Subject matter Social concensus on definition Broad codes Builds cognitive structure Meaningful Schema Traces of cognitive acts Chunking Coding Organizing Classifying Cognitive Maps	Conservative vs. gambling strategies Impulsivity Imagery Field Dependence Social Desirability RAT Matching of instances e.g., auditory intelegraphy	Provides wide number of examples Blocks instances that go together Once material is learned provides student with opportunity to make refined discriminations Tests for application of material Broader objectives - but can be clearly stated	Perceives details of each instance --- discriminates and abstracts relevant attributes	Primarily a function retrieval processes Organization an important factor. Activity engaged in by learner as important as the characteristics of the material

(Cont'd)

Table 1 (Continued)

Descriptors, Teacher-Student Activities and Individual Differences (ID's)

Related to Learning and Remembering Each Kind of Transformation

Type III Transformations: Inferential

Descriptors	ID's	Teacher	Student	Remembering & Forgetting
Search Process Oriented Rule formations Employs cognitive structure Information processing Strategies for changing hypotheses Novel solutions Synthesizing Decisions Inferences Problem-Solving Creativity	Strategy Preferences Anxiety Amount of relevant knowledge RAT Rigidity-Dogmatism Number of rules available Delay of gratification	Emphasizes strategies employed by student Uses discovery and inquiry techniques States objectives in terms of problem-solving outcomes rather than content-oriented outcomes Emphasizes process rather than content	Scans information stored in long-term memory Restructures problem Employs alternative hypotheses Changes hypotheses Evaluates obtained solution against desired characteristics of required solution	Retrieval processes important but here the strategy for retrieval is as important as the way the output is organized

Selective Attention

In overview and within this framework, we assume the behavioral cycle, following a motivational phase, is initiated with stimuli or, more broadly, with incoming information. This incoming information can only be in a form acceptable to the senses. For example, in its most primitive form it is only a conglomerate of sounds or figures. One might be tempted to say that incoming information is received as a pattern of sounds or figures. That is incorrect, for in its most naturalistic form it is amorphous and undifferentiated. The fact that the observer supposes it has pattern is because the material has been transformed in some way ... that is, at the very least, the learner has attended to some attributes of the incoming stimuli while excluding others. Similarly, because of such characteristics as intensity or brilliance other attributes may be more salient than others and so, too, may gain the student's attention ... one of the first steps in transformation. Or, because of previous knowledge and encounters with the environment he has acquired a conceptual pattern which he imposes on the new experience, thereby "making" some attributes more salient than others.

Since only some stimuli are processed, the initial phase is called selective attention. In this process, the relatively inexperienced learner will make gross selective responses to stimulus differences; the relatively experienced learner will make refined differentiation of patterns; and the advanced learner will make abstractions of higher order structures (Gibson, 1969).

The Image

The outcome of selective attention is a percept, one of the first internalized transformations of external stimulation. The exact nature of the percept is dependent only in part on content emphasized by the instructor. Despite the teacher's effectiveness, the percept will be influenced by the student's dispositions and previous experiences, or in other words, by his developmental history. Although one can understand much about the present state of the student, as influenced by his developmental history, through psychometric techniques, the prior experience of the student cannot be completely controlled under present educational circumstances. At the present state of the art of teaching, the most that can be done by the instructor is to learn about it and adapt to it as best he can.

The percept, as it is being used here, is analogous to whatever is implied in the terms image or ikon but not necessarily a picture that can be "seen" by the learner as implied, for example, in discussions of eidetic imagery. The first images in rule-formation and other higher mental processes are probably very close to the initial direct experience. Later experiences appear to be enfolded into images already available to the student, in which case the image becomes more and more an idealized or highly generalized pattern with increases in experience. Later experiences are departures from the original to the extent there is breadth of experience with the object. The importance of the image is indicated by Pribram (1967) who indicates in his " The Four R's of Remembering" "...the understanding achieved by research in brain function in my laboratory suggests that the present educational effort is deficient in the techniques of image-making and in the lack of emphasis on the reconstructive aspects of remembering" (p. 18).

The Function of Labels

Although storage presumably can remain at the ikonic level, especially if the learner is incapable of employing symbols (e.g., such as a young child), or prefers not to do so, it is likely that most adult students can and do label percepts by verbal symbols. They attach names to their experiences and thereby make the experience a much more embracing one than it might otherwise have been. Thus, the immediate experience can be subsumed under a more general experience or linked to an earlier one by a word, a sentence, or other symbol. This process can be both an advantageous and disadvantageous one. By itself, the percept is distincitve. If it were not labeled it would remain isolated and would retain its discriminability from other experiences. Accordingly, it would be easily identified but would be susceptible to major sources of interference. However, upon being linked to an earlier, already existing, experience via a symbol, discriminability can be lost if the experience becomes assimilated as a part of the template for which the label stands. Interestingly in this regard the label can determine what is retained ... and these can be quite different depending on the context provided. Thus, if one were to call a "cardinal" a "bird," recall and transfer will be entirely different than if the "cardinal" is described as a member of the clergy. What is important then, is not only that some transformation is accomplished, in the sense that incoming information is linked to existing knowledge, but that discriminability is simultaneously retained.

There have not been many experiments performed in this area, but those that have been conducted are clear in their implications. Both Stewart (1965) and Di Vesta (1971) have shown that a visual stimulus (e.g., picture) followed by a verbal label is more easily recalled than when the verbal label is followed by a picture of the referent. The implication for instruction is that the picture must precede the labeling. Furthermore, there appear to be two processes ... one for recognition and another for recall. If the teacher's objective is only to have the student recognize the material to be learned, it is best to put this material in picture form, if it can be so adapted. Item for item, a picture is recalled better than a word ---- again pointing to the importance of the percept. However, if the instructor's objective is that the student should recall much of the material learned, without the benefit of specific cues, then some combination of labeling and graphic presentation should be provided.

The results of an experiment in this area are most interesting. Suppose the experimenter presents a list of words with the instruction that the subject is to recall as many items as possible. Then a recognition task with the same word list is presented, followed by still another study presentation of the same words. After all this is done, the subject is asked to recall as many of the words as he can. Studies within the present program (Di Vesta, 1971) indicate that, under this sequence (word-word-word) the subject recalls fewer items than he would if at least one of the phases (i.e., first presentation, recognition task, or second presentation) contained pictures instead of words (e.g., word-picture-word or picture-word- picture). Apparently, the use of pictures along with the verbal label, whether before or after the pictures, improves discriminability and hence recall. The best combination of procedures for instruction that enhances free recall, if we can extrapolate from our experiments with simplified learning materials, is to follow pictorial presentation of materials with presentation of verbal symbols (i.e., labels) and then to "remind" the student of original learning by another presentation of pictorial materials (i.e., picture-word-picture). This procedure is to be contrasted with the best one for recognition. The recognition task involves an initial presentation of a list of items followed by another presentation (recognition trial) of items. The subject is instructed to indicate which of the items on the recognition trial he had seen on the first presentation. In this task, the most effective procedure is pictorial presentation followed by pictures as cues (i.e. , a picture is presented and the subject is asked whether he saw that picture on the presentation trial) on the recognition task as would be expected. The second best procedure is the presentation of pictures with words as cues in the recognition list. Words in the learning list with pictures as cues for the recognition task is third best and finally presentation of words followed by words as cues are recognized least efficiently. These results all point to the importance of the percept-verbal transformation; the most elementary of the cognitive transformations with which the instructor must deal. They also indicate that clarity of the stimulus to the subject (picture with word cues) is more important than clarity of the response (words with pictorial cues).

Transformational Stages

In higher cognitive processes incoming information is typically processed beyond its imaginal components. It is assumed, in this discussion, that there are stages of transformations which form a hierarchy. Each stage though related to some extent on learning in the previous stage involves unique processes and result in outcomes distinctly different from the previous stage. From an instructional standpoint this notion implies that any instructional strategy must be based on these considerations: the identification of outcomes to be achieved; the student's stage of learning for a given outcome; and the teaching method(s) most appropriate for the stage of learning and the desired outcome; and the variables uniquely associated with a given stage (see for example, Table 1).

The analysis and synthesis of ideas presented here are based on a number of cognitive theories related to learning including those described by Ausubel (1968), Biggs (1971), Miller, Galanter and Pribram (1960), Neisser (1967), and Gibson (1969). Although in some respects the present integration has the features of a hierarchy in common with Gagne's (1970) framework, there are important differences. Thus, the three types of transformations presented here represent what are believed to be qualitatively different processes. On the other hand, Gagne's (1970) kinds of learning tend to overlap and are often distinguishable mainly on the basis of labels provided. For example, a fairly reasonable argument can be made that Gagne's Types I (sign-learning), II (response learning), and II (chaining) require very similar processes and tend to be representations of a fundamental kind of learning. A similar case can be made for verbal associations and multiple discriminations, or for multiple discriminations and concept-learning. Accordingly, the distinctions among categories are not always clear in terms of process. It is hoped that the present framework will provide the beginning of a model for describing the teaching-learning process in a way that will describe essential variables that must be considered by the instructor and that will permit the deduction of testable hypotheses.

Type I Transformations

In earlier theories, Type I transformations might have been described as associations. The variables related to "fixing" or "strengthening" associations involving drill, repetition (with motivaton, of course), meaningfulness, and relatedness, all of which increase frequency and familiarity with the items to be recalled. The importance of any instructional strategy which increases the frequency of experience with an item, should not be minimized, since the evidence for the positive effects of frequency on retention of materials learned in rote fashion is overabundant. However, to these principles there must be added another dimension with which the instructor must contend. That is, that students begin with percepts when learning material in fields unknown to them. In the initial stages of learning, these materials had best be presented in a form that will enable the acquisition of details that comprise "percepts" --- for example, presentations in pictorial form by still pictures, motion pictures, laboratory demonstrations, gestures, and the like. But more importantly, it is to be emphasized that students go from these percepts to symbols --- typically verbal symbols. However, it is not at all unlikely that students may proceed through intermediate transformations that culminate in an idealized "template" which is then labeled via a verbal symbol.

Type I transformations need not be rote learning though they are often taught that way. As Pribram (1967) suggests:

> "...lecturers should present but few facts that are to be remembered unless these are unobtainable elsewhere (in which case precise note-taking is to be encouraged or hand-outs given ahead of time). Rather a lecturer should arrange and even rearrange material which the student can, with informed guidance, find for himself. Each set of lectures should provide a framework; each lecture, a core idea on and around which the student can build for the remainder of his life.
>
> Further the student must be prompted by his instructors to make his own rearrangements. He can do this in term papers and in research endeavors, and he will, of course, use his instructor's lectures as models. If these are sufficiently flexible in approach, the student's work will reflect this" (Pribram, 1967, p. 30).

Type II Transformations

The percepts, which presumably are analogous to integrated visual (in a figural rather than literal sense) scenes rather than retinal snapshots, associations, and labels, are precursors of transformations at the conceptual level. These products of the first stage of learning become differentiated, combined, and integrated in different patterns corresponding to concepts, ideas, and thoughts. The student may abstract distinctive features, abstract invariant relations, and detect higher order structures. More importantly, however, he puts these together to form new representations. Although it seems highly likely that percepts may play an important role in this process, it seems that at the higher cognitive levels the percept takes on the form of an idealized template, perhaps even with some degree of flexibility. Thus, for example, the percept "bird" initially can be a relatively fixed image of a sparrow but after a variety of direct and vicarious experiences with "bird" the percept becomes a idealized "transformation;" it becomes in every sense of the word a symbol. The fully developed transformation is flexible. It can be expanded to encompass a large class of objects or it can be restricted to encompass only an exemplar of the class. Differentiated transformations, whether isolated, combined in patterns, or integrated with other percepts can also be labeled with verbal symbols in which case the verbalization tends to reflect the differentiation or new integration, but also has the advantages of being easily stored and easily manipulated in thought processes.

From the standpoint of instructional strategies the formation of concepts consists of learning to categorize experiences, or to classify (categorize) stimuli. However, it is probably more accurate to say that concept formation is part of the generic process of coding whereby a sub-process involves learning to classify percepts or the symbols by which they are labeled.

Most informed observers discussing instructional strategies would agree that all courses, from the most introductory to the most advanced, contain numerous, perhaps thousands, of concepts. What is less obvious but much more important is that a discipline itself is comprised of classifications of environmental events that are unique to that discipline and different from classifications in another discipline even though both disciplines deal with exactly the same "events." Thus, the distinguishing characteristic of a subject matter area is the nature of its concepts. English has its unique set of concepts based on descriptors of the properties of sentences, paragraphs, poems, prose and the like. The concepts of physics organize environmental events in other ways. And so it is with music, chemistry, biology, mechanics, art and so on. An important feature of conceptual transformations is that they emphasize certain (relevant) attributes while ignoring other (irrelevant) attributes.

This view is consistent with a number of current theoretical notions involved in research on learning. Particularly important, for example, are the distinctions between template-matching and feature analysis in pattern-recognition (Neisser, 1967). Also important is the distinction between the processes of elicitation of associations by images vs. the labeling of images. The evidence (Paivio, 1963; Paivio & Csapo, 1969) suggests the latter is the more dominant process. Plans for further development of the theory include incorporation of such processes.

The saliency or dominance of attributes provides a basis on which mediation can occur. Mediation permits the learner to generalize to other classifications and so facilitates the formation of new concepts. In the sense that it facilitates transfer, mediation is a bonus of learning where it is involved! Perhaps its most essential requirement is the use of language. Thus, to put a verbal label on an experience (after a verbal label has acquired meaning) is to mediate, call attention to, certain of its attributes. To put another verbal label on the identical experience is to call attention to other of its attributes.

An instructional strategy for helping students achieve conceptual transformations is the presentation of a variety of exemplars or representative examples of the concept. The student is then required to label these exemplars, and at some point to identify the defining attributes and their combinations with which the label is associated. Concepts deal not only with straightforward presence or absence of attributes, together perhaps with an operator such as "and, " " either," or "both", for combining them, but also deal with relationships among dimensions.

Concepts too are cumulative in their growth. Most investigators such as Glaser (1968, p. 21), Gagne (1970), Carroll (1964, p. 190) and Suppes (1965) speak of the hierarchical structure of concept formation. New concepts are generally built on existing ones. This can be an advantage in the sense that previous experiences can be fruitfully employed in teaching new concepts as in concept identification, for example. However, prior concepts can be disadvantageous to new learning where bias can direct attention to the wrong attributes.

Type III Transformations

Type III transformations lead to radically different outcomes than are typically achieved at either the reproductive (Type I) or conceptual levels (Type II). This third kind of transformation includes such outcomes as productive thinking, problem-solving, inferential thinking, and the like. In these behavioral outcomes we find, as in the other kinds of thinking transformations, such processes as perceiving, selecting, and abstracting. In the conceptual transformation what is abstracted is typically well defined by the instructor, at least. If he is skilled it will be pretty well-defined for his students through his behavioral objectives or through other techniques of making the correct attributes salient.

At this juncture, however, conceptual transformations and inferential transformations part company. As the student abstracts he may change the direction of what is abstracted in order to obtain new inferences. He thereby selects attributes other than those commonly identified. More importantly, however, he may combine or organize these attributes in any number of combinations to suggest alternative and unique outcomes and relationships. There is some generalization (transfer) from previous learning involved here, of course. Nevertheless, it is not the sort of generalization in which the person is committed to the "right" answer or to the solutions which comply with social convention. It is a generalization in which the individual can relate what he has found to a wide range of situations and in unique ways.

Outside of some perceptual theories and some notions that lateral transfer may be related to innate characteristics of the individual, there is no theory known to the present author which does not presuppose the importance of cummulative knowledge in Level III transformations. Ausubel (1968) for example, suggests "...that the existing cognitive structure plays a key role in problem-solving is evident from the fact that the solution of a given problem involves a reorganization of the residue of past experience so as to fit the particular requirements of the current problem situation. Since ideas in cognitive structure constitute the raw material of problem-solving, whatever transfer, positive or negative, occurs, obviously reflects the nature and influence of cognitive structure variables .... Without [the possession of relevant background knowledge (concepts, principles, transactional terms, available functions] no problem-solving is possible irrespective of the learners degree of skill in discovery; without it he could not even begin to understand the nature of the problem confronting him." (Ausubel, 1968, p. 538). Bartlett (1958) describes experimental thinking as a "...relatively late development in the search for knowledge of the world, since it has to be based upon much prior accumulation, description and classification of observed facts ... The basic challenge to experiment comes when events and phenomena which have appeared to display differences to immediate observation are seen, or suspected, to possess overlap and agreements ... it is opportunistic by nature ..." (Bartlett, 1958, p. 160). In writing about the educational conditions considered most likely to produce broad, flexible codes (diversity) Biggs (1971) says, "These conditions are very different from those appropriate to developing the skill codes [those that govern the performance of skills] ... the essential things about the kinds of codes involved in process learning here is that they are broad, flexible, and of an abstract nature. The most important feature is that the code is an abstraction from specific experience, and so it follows that the more varied the experiences are that lead to the construction of a code, the more generalized the code will be" (Biggs, 1971, p. 106). Gagne's (1970) hierarchy of learning in which problem-solving is the last stage, is based entirely on cumulative learning. And, Neisser (1967) indicates, "Even if the constructive nature of memory is fully acknowledged, the fact remains that information about the past must be somehow stored and preserved for subsequent use. To-day's experience must leave some sort of trace behind if it is to influence to-morrow's construction" (p. 280).

According to Neisser (1967) it is the traces of earlier cognitive acts that are stored rather than the outcomes (e.g., information) of those acts. Pollio and Foote (1969), in interpreting Bousfield's (1953) work on "category clustering" suggest that learners do not necessarily retain specific category items but rather subsume them under more general rubrics such as the category name. Thus, earlier constructive (as opposed to reproductive) activity becomes the important feature of the trace. Presumably, there are no stored copies (such as eidetic images or verbatim sentences) of the finished mental events. As a consequence there is a great deal of flexibility provided to the human learners cognitive activity. Traces of processes are flexible; stored eidetic images or verbatim sentences would be relatively inflexible.

If it is assumed that a store of information is a prerequisite for Type III transformations then understanding how the retrieval of that information is accomplished becomes a critical issue.

In Pollio and Foote's (1969) terms it is suggested that once a category is recalled, items are regenerated or reconstructed on whatever bases groupings had been accomplished. In this feature of retrieval Bartlett (1932, p. 311, 312, 314) as cited by Neisser (1967) indicated that memory is constructive. These authors all indicate that new ideas do not emerge according to what Neisser calls the "Reappearance Hypothesis". Precise repetitions, implied by the Reappearance hypothesis, are relatively difficult to achieve except after long practice and are the exception in behavior rather than the rule. Conversely, there is a great deal of variation in retrieval of information. Organization and reorganization of material may vary because of one's values or interests, and, thus, is not elicited in direct correspondence to input patterns.

Advantageously for inferential and other productive processes the learner can focus on one or another aspect of the situation, that is, he can choose what he attends to. As Pribram (1968) indicates, during registration of the incoming information there is an orienting reaction and its habituation. These processes allow the learner to isolate the spatial and temporal elements of an event and minimize interference among events. Although registration permits time for such processes as rehearsal, its most important function is to aid the learner in deriving meaning from the situation or providing structure for it.

Within the framework suggested by Neisser (1967) recall via images occur when the new construction (organization or structure) is largely under control of the remains or traces of an earlier one. On the other hand, recall in words is more flexible. It is a new verbal synthesis and can include information from a variety of sources, traces of earlier verbalizations, visual images, and reconstructions as well. A primary feature of verbal synthesis, compared with imagery, appears to be greater flexibility.

From the aforegoing it is apparent that some form of cognitive structure is constructed according to which the information is retrieved during recall. An important dimension of problem-solving and inferential processing is that these processes are not dependent on the immediate past as, for example, "the present stroke may be dependent on the past stroke" in skill learning. Rather, information is stored according to a schemata, i.e., a skeletal plan into which ideas may fit and which, in actuality, may direct the reorganization of ideas (Miller, Galanter & Pribram, 1960). It is non-specific to begin with, though it is certainly organized ... just as the framework of a house in its initial stages is organized yet relatively nonspecific.

This framework ... in part exemplified by a problem statement and the subgoals by which it is defined ... directs what will be retrieved from memory. This point can be readily seen in the process of subjective organization wherein the learner does not recall a series of items in the order in which the list was presented. Rather he retrieves the material in terms of one category and then another. It follows, as Pollio and Foote (1969) imply, that if the learner were told the 'rule' by which a categorized list was constructed, this information would facilitate the storage and or reconstruction stages of memory thereby leading to increased clustering and greater total recall. Nevertheless, in problem situations characteristic of Type III transformations much depends upon what the learner is trying to achieve.

In Type III transformations, as indicated earlier, there is considerable coding flexibility ... exisiting codes can be reshuffled readily to cope with slight but significant changes in input. At the schemata level, too, the plans of the learner can be changed; he is not dependent on the transformation based on more or less specific attributes, for a more or less standard outcome, as he is in concept learning but can (must) adapt the schemata to sub-goals, related to long-range goals, as necessary.

Type III transformation depends on the adequacy of the strategies employed by the learner. A good strategy is one that economically abstracts the relevant information and eliminates the irrelevant information (noise). Presumably, there have been developed recursive subroutines from experience. All told the process is complex ...

consisting of continual search and reconstruction but the emphasis remains on the processes ... searches through memory, strategies, and the like. This emphasis is not so difficult to understand if we assume that at the higher levels, memory stores information about processes rather than about contents (e.g., see Neisser, 1967, p. 296).

Cognitive Structure in Transformation

Cognitive structure refers to the store of knowledge ... facts, ideas, and processes ... held by the learner. In this regard, Ausubel (1968) has said, "If I had to reduce all of educational to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (p. vi). An important feature of the cognitive structure is the way in which the material is structured or encoded. It can be in the form of narrow codes or broad codes (Biggs, 1971). Narrow codes are best exemplified by those found at the lowest level of Type I transformations where materials are processed in approximately the same form as they are received. Broad codes are more inclusive categories which provide for integrative reconciliation (that is, they enable the learner to relate many varied, and even divergent experiences) and for discriminability (that is, they enable the learner to keep ideas separate despite their relatedness). If these two characteristics are present the learner will have access to a large number of ideas and, simultaneously, can make an indefinite number of combinations from them --- a point which is especially important for Type III transformations. Furthermore, the formation of these categories as a part of the cognitive structure provides for the subsumption of new information. Without such categories material is associated by rote (see quote from Pribram on page 1).

As important as cognitive structure is in the development of schemata for directing the storage and retrieval of information, it can have some negative effects as Ausubel (1968) implies in the notion of obliterative subsumption. In the first place, exisiting cognitive structures are idiosyncratic and correspond to the unique experiences of the learner. Accordingly, they introduce bias and distortion into the initial construction of schemata and into their later reconstruction. Secondly, when an idea or experience is encoded under a given category it may not be retrievable in new situations unless some provision has been made for integrative reconciliation. As an example, a student may never see classical conditioning as involving reinforcement or as a case of sign learning unless he is permitted to discover this for himself. Thirdly, an idea or experience encoded under a given category may be irretrievable because it was learned as congruent with the category without provision for discriminability. For example, on occasion one finds a student who has subsumed "extinction" under "forgetting" and eventually sees the two processes as identical. Note that discriminability could have been provided by noting such contrasts as "extinction is the loss of the availability of a response as a result of conditions existing during its occurrence;" and "forgetting is the loss of the availability of a response because of disuse."

Strategies for Transformations

Our emphasis on process earlier in this chapter may have sidetracked the reader from recognizing that implicit in the notion that processes are learned is the supposition that learners find strategies for identifying structures through grouping of units. Such groupings, especially in higher forms of transformations, are abstract. They may not be readily identifiable to either the user or the sophisticated observer. Nevertheless, the work of Miller (1956) implies that symbols are coded into chunks, into organized units.

The way in which the units are put together are called rules. Rules, then, are the essence of structure in symbolic learning. Unfortunately, we know little about how rules are formed or how items are organized into higher order units. The work of Chomsky (1957), for example, describes the way in which grammatical transformations occur and the rules by which new transformations in language are generated but tells little about how the transformations are acquired. Similarly, Esper's (1925), now classic study, suggests that learners do use rules but provides little understanding of the processes for forming these rules.

Gagne (1970) defines a rule as "*an inferred capability that enables the individual to respond to a class of stimulus situations with a class of performances*." In terms of Gagne' s hierarchy of learning it belongs in the inferential transformations, being placed between concept learning (sixth in the hierarchy of end-products) and problem-solving (eighth in the hierarchy of end-products of learning). As such, he suggests that rule-learning can only be accomplished after all other sub-goals prerequisite to formation of the rule have been reached. That is, the learner must have made discriminations among specific items, identified verbal mediators to link these items to his cognitive structure, organized the specific items, on the bases of these mediators, into concepts, which, finally, are put into various relationships with one another as rules. The question of how such relationships (on the inferential, problem-solving, or any of the other higher forms of processing) are formed remains to be answered. Note, that it is a relatively simple matter to teach learners rules that are already known. The difficult task is to identify the principles by which learner's acquire the strategies so necessary to forming the new rules.

It is not the intent in this discussion to distinguish all possible strategies and individual differences associated with transformations. There would be too many. However, the relationship between the learner strategy and individual differences can possibly be illustrated by describing search strategies. Regardless of the strategy he uses the learner searches for a correct solution from among a number of alternatives. He has hypotheses which direct his search. He employs the information he gains from testing one hypothesis to reduce the size of the set of alternatives for his next test of the alternative that might be the correct one.

Not all people attack the task, whether in achieving a conceptual transformation or an inference in the same manner. Bruner found that the system of search, that is, the strategy employed differed from person to person. Some learners used a gambling strategy, going from one to another, without good reason and without being able to use whatever information accrued from that trial on subsequent occasions.

Others used a conservative focusing strategy, in which they remained with sub-goals and in which they systematically eliminated sets of incorrect alternatives. A highly systematic strategy would be to identify all possible alternative hypotheses, keep them in mind, make a test of one, then on the basis of information from that test, scan all the remaining ones and eliminate those which are inappropriate. Learners use this strategy infrequently since there is too much to remember; the cognitive strain is too great.

Inferential transformations require, essentially, the use of search routines. It can be assumed that some strategies (that is, methods by which hypotheses are changed within a learning situation) can be acquired through training. Nevertheless, as a consequence of experience, and possibly of some innate characteristics, learners can also be differentiated according to their preferences or their abilities to use one strategy over another. For example, Ingersoll (1970) decided that adults could probably benefit equally well from materials presented auditorially or visually. He reasoned further that differences in performance when the two types of tasks were presented simultaneously were due to preferences for employing one modality over the other if there was a choice in the matter. Without a choice, differences would not be demonstrable. On the other hand, the differences in verbal and spatial relations abilities in men and women appear to be due to differences in abilities (or aptitudes) rather than to differences in preferences. When considering investigations of variables affecting the use of strategies, it seems essential that the investigator of aptitude by treatment interactions should attempt to distinguish whether the use of a given strategy is primarily one of aptitude or of preference.

Sanders and Tzeng (1971) found a predicted interaction of preference for a strategy with rote versus concept learning though they found no interaction with verbal ability. We suggest, too, that some strategies, such as imagery, may reflect *ability* differences when the learner is in the primary grades but may reflect a *preference* when the learner is an adult. This distinction can be a most important one in experiments designed to identify disordinal aptitude by treatment interactions.

Retention and Forgetting

Currently there are many models and theories regarding retention and forgetting. One basis for classifying them is the extent to which they emphasize variables affecting recall through conditions existing at the time the material is (a) in short-term store; (b) being consolidated and processed (encoded) for long-term storage; or (c) being retrieved. Another basis for classification is the extent to which the theories emphasize the influence of (a) the learner's existing cognitive structure; (b) the learner's activity during storage or retrieval; (c) the qualitative characteristics of the material, e.g., its affective qualities, and familiarity; or (d) the characteristics of the presentation of the material, e.g., whether categories have been implicitly or explicitly built into the material; or whether the materials presented in random or blocked fashion. These variables appear to be differentially related to the three types of transformations, as implied in Fig. 4-1.

Typically, Type I transformations must be considered as elementary learning, they bear a direct relationship to experience. Although any learning can be acquired in a meaningful way, that is, relatable to

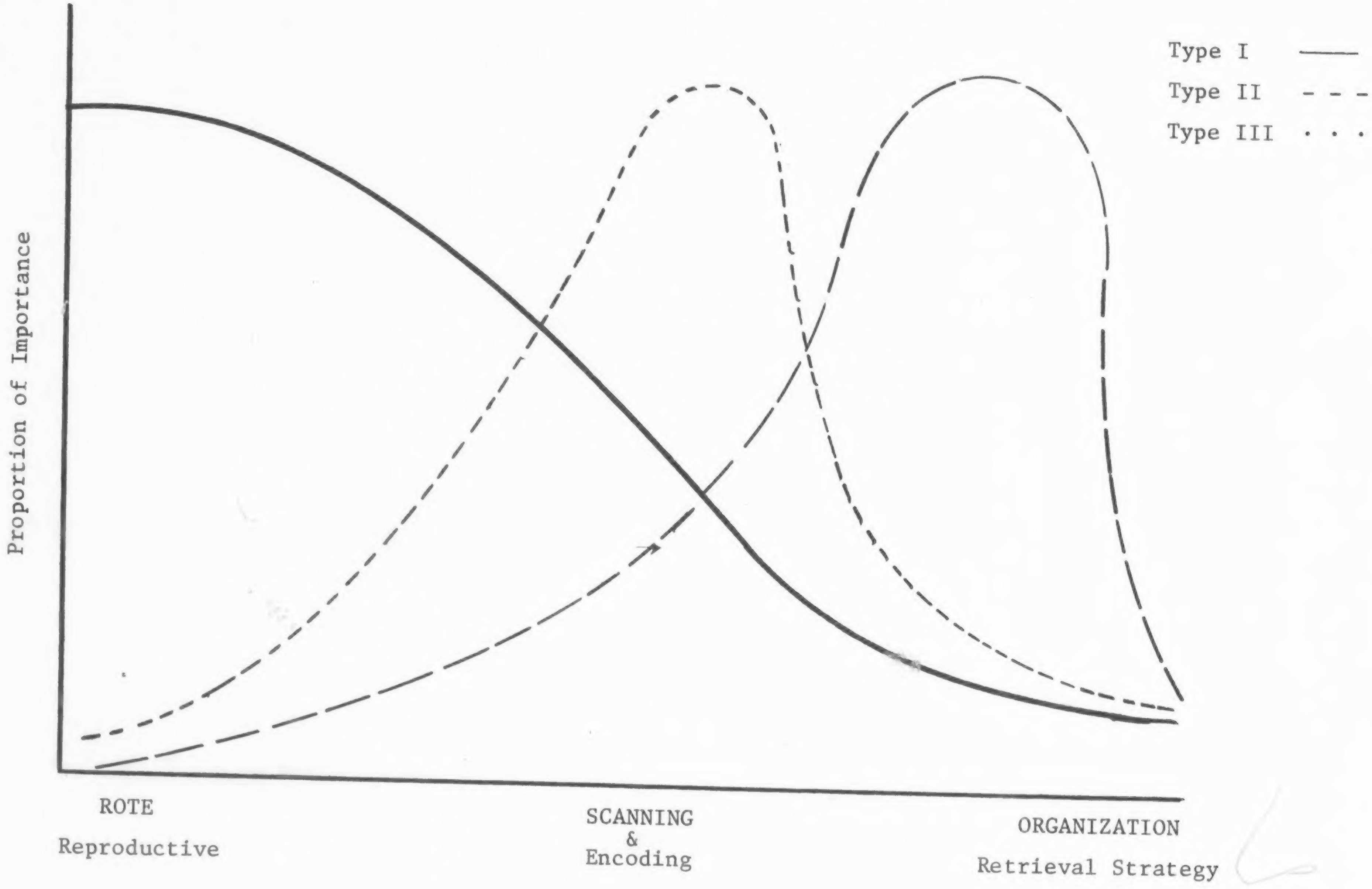

Fig. 4-1. The relative importance of differing degrees of organizational strategies versus rote memory in recall of Types I, II, and III transformed materials.

existing knowledge, instruction often leads to learning at a minimally meaningful level. Furthermore, it is probably the case that in the early stage of learning any acquisition is necessarily rote, elementary, or verbatim. In other words, the material is first stored as discrete, isolated items. This point gains some support from a study by King and Russell (1966) as cited by Gagne and Rohwer (1969) who say, "[These data] suggest that the activity of storing main ideas for recall entails the storage of verbatim material as well" (p. 388). As Ausubel (1969) contends, the primary goal of the student, who directs his learning activity only toward Type I transformations, is to build and maintain associative strength among units or items to be learned. Such students may, for example, only memorize the sequence "momentum equals mass times velocity" as a series of units (words) which follow one another; or they may only memorize a list of events leading to the 1968-1969 recession as a series of associations. In either case, if only the most elementary form of Type I transformation has occurred, the learner acquires only isolated events and the contents of his memory resembles very closely the formula or the list as presented. Nevertheless, as Gagne and Rohwer (1969) suggest in reviewing the King-Russell results, "[Possibly] effective verbatim memorization begins with a kind of learning that, despite its appearance, is not at all rote in its underlying processes .... subjects [engage] in considerable covert activity during performance on presumably rote tasks .... These activities vary in character from simple rehearsal to complex grammatical contexts; they will be referred to as elaborative activities" (p. 388).

Retention of such material has been examined extensively in laboratory situations where subjects learn via rote means. The variables affecting remembering and forgetting at this level are those concurrent with the learning situation. Thus, learning is influenced by contiguity, frequency (i.e., practice) and reinforcement. These variables, and others associated with them at the time of learning, have their effects on later recall. Accordingly, the findings are that distributed practice in original learning results in better recall than massed practice. Concurrent interference due to intralist and interlist similarity during learning can have debilitating effects on recall of the material as can response competition, and stimulus and response generalization. Whenever the original learning situation differs from the recall situation either because of a change in cues provided by the instructor or by a change in the learner's set, recall will be affected detrimentally.

Overlearning of the material, i.e., extensive practice beyond the time when the student can meet some minimal criterion such as repeating a list of events without error, is helpful for retention of rotely learned subject matter. On occasion the student may also attempt to employ a mnemonic aid, e.g., "the 30 day hath September ----" rhyme to remember the number of days in the months, or he may employ the C. HOPKINS CaFe mnemonic to remember the elements in the soil. These are all attempts to make material meaningful, which merely means that there is an attempt to code the material or to relate it to some aspect of one's cognitive structure or experience. Mnemonic systems of this sort have been extremely useful in aiding the experimenter in understanding the important process of encoding. However, within instructional settings mnemonic aids must be considered as the crudest and most rudimentary means by which subject material can be made meaningful. Other means, more important for instructional strategy are described in the remainder of this section.

Types II and III transformations are meaningful kinds of learning. Retention of this material depends as much upon how the material has been stored and the conditions under which it is retrieved as it does on the conditions present during learning. In fact, a number of model builders suggest that the major problem in understanding the memorial processes is one of understanding the retrieval of what has been learned.

The goal of learning at these levels is based on the formation of superordinate structure, i.e., experiences are organized into hierarchies according to rules. It appears that such hierarchies can be established by repeated elementary operations, thereby providing some support for the notion that elementary learning (rote or Type I) typically precedes meaningful learning. (Sanders and Tzeng's [1971] study suggests that Types I and II learnings are not hierarchically related and that individual differences in preferences for Types I and II learning are important. However, it is suggested that clearer tests must be made before the hierarchical notion is abandoned.) Thus, recall of Types II and III transformations are, unlike Type I transformations, comprised of organizations or structures based on specific attributes of the material to be learned, (a) as perceived by the learner and (b) as affected by what the learner already knows or has experienced.

These structures are called by a number of names in the current literature: schema, traces of cognitive acts, trace, processes, rules, or decisions. What is more important is that these terms imply a dynamic ongoing organization during recall of the way the learner processed an event. There are progressively higher levels of processing into superordinate categories much as language is organized. The relationship of the subject's knowledge (cognitive structure) to his performance is clearly emphasized in this approach. What we now want to know, as researchers and instructors, are the answers to such questions as "What is the learner doing to the task materials?" "What is he doing with the materials?" "How were these materials being encoded?" "How has what he already knows affected his recall?" (See quote from Ausubel on page 18.) The learner is thereby viewed as an active processor.

Two examples will help to illustrate the importance of this view. In one experiment the subjects on one condition were given a semantic task, that is, they were instructed to make a semantic analysis of the task materials which were highly organized into hierarchical structures. Simply, they were required to pay attention to each word but in the course of doing so had to pay attention to the meaning of each. In the other condition, the subjects were administered "incidental instructions" for the same task materials. In this latter case, they had to attend to each word because their task was to identify the number of syllables and letters in the task materials. The results indicated that the semantic analysis worked in favor of high recall while the incidental instructions and attention had no effect on recall. Thus, secondary organization in memory is semantic, it is only secondarily a matter of external organization, that is, of organization imposed on the material by a textbook writer, a researcher, or an instructor. If externally imposed semantic organization is available it will enhance learning over material which is not so organized, but even here retention will be enhanced further by the learner's activity ... activity is the essence of dynamic recall processes. If discovery learning has an advantage over other methods of instruction, for recall it may be because the learner can link what is being learned to his own experience; he finds his own encodings. Compare this with the typical view of instructors who by implication suggest their encodings correspond with "reality."

From Ausubel's (1968) point of view the important elements in encoding are (a) subsumption ... linking what is being learned to existing elements of the cognitive structure; (b) dissociability ... retaining the characteristic individuality or distinctiveness of the new material from existing knowledge; and (c) integrative reconciliation ... perceiving relationships of the new material to several aspects of the cognitive structure or, stated somewhat differently, cross-indexing new material with existing knowledge while retaining the distinctive character of each.

Another aspect of a dynamic memory is that it is characterized by synthetic integration. Thus, the question can be asked, "What effects does a previous experience have on the recall of another experience?" Although such questions are currently being raised by contemporary investigators of the memorial processes, Bartlett (1932) must be credited with the first description of this process. He observed that in "real life" learning there is not only a reduction in quantity of what is remembered of the original learning situation but also in quality. The recall of meaningful material is different from the original; it had been transformed. The direction this transformation will take is predictable not only from the learner's past experiences but also from his beliefs, values, needs, emotions and present circumstances. Bartlett (1932), as we have said in an earlier section of this paper, described such transformations as constructive. He argues further that the principles governing recall of Type I transformations, in our terms, are not the same as those governing the higher order transformations involved in prose-like materials or coherent passages. When one of his subjects, an anthropology student, was asked to recall the events in an unusual supernatural Indian story (The War of the Ghosts) the subject made the story comprehensible to himself by calling the ghosts, a class or clan, and carried out his transformation by unwittingly capitalizing the G - - - - in ghosts whenever it was written subsequently .... A special interest of the subject had effected an unrealized distortion (transformation) of what had been remembered.

These transformations or distortions are conventionalized to the idiosyncratic nature of the individuals cognitions. They are simplifcations of experience and economical. The experience is made to correspond to those with which the individual is already aware. Consequently, as Biggs (1971) indicates there is less strain. He further indicates that "These implicit assumptions have been formed through past experience ... contradictory experiences are simply misread; they are not even seen to be contradictory ... if we didn't have this economizing tendency in learning and remembering, the strain of coping with the sum total of information ... would be intolerable" (Biggs, page 25). This tendency seems to be a pervasive one. The present writer has observed in his own teaching that students will attempt, almost compulsively, integration and rationalization by asking such questions as "Well, isn't that concept (X) you are talking about very much like 'So-and-So's' concept (X')?" Such questions are fortunate, especially when the transformation amounts to a distortion of information, for then the instructor can help the learner to encode the material in the appropriate "pigeon-hole." If this is not done, the learner in all probability will recall the material as "So-and-So's" concept rather than the desired encoding. Accordingly, a part of instructional strategy must be to provide the learner with an opportunity to make his conversions of information public.

Memory, Strategies and Cognitive Styles

There is a kind of progression of requirements, across the three levels of transformations, for remembering and for the use of strategies. Thus, for Type I learning raw memory, the kind measured by the digit-span test, is extremely important if that material is to be used later on. Strategies are important, too, for Type I transformations but, as indicated previously, such strategies tend to take tne form of simplified, if not artificial strategies such as those exemplified by mnemonic aids. Type II transformations also require memorization but strategies are of equal importance. The learner must first know how to attend to an experience, how to get information (meaning from attributes) from it and how to encode or store it; that is, he must have a strategy or strategies for each process. Then, he must be able to retain that information for later use, i.e., he must remember it in order to link it to other similar experiences. In Type III transformations, the primary requirement is to retrieve information already stored in ways that correspond to the demands of a problem or query. Type III transformations are as dependent on strategies for scanning and for retrieval as they are on memory and in all probability are more so.

There are a number of strategies that can be employed at any one level. A description of such strategies in concept formation has been described by Bruner, Goodnow and Austin(1956) and was summarized above under the description of Type II transformations.

The idiosyncratic nature of strategies was emphasized by Restle (1962) who indicated that in discrimination or cue learning problems subjects have difficulty because their strategies conflict with those the experimenter expected them to use. Thus, he indicates that cue learning involved the selection of responses rather than the formation of a series of bonds or associations. Most subjects in such situations have a variety of strategies available to them; the learning problem reduced to one of identifying the strategy that will always yield the correct (rewarded) response ... the one intended by the instructor or experimenter. Restle's model indicates that the learner can employ (a) one strategy at a time; (b) all strategies at once; or (c) a random sample of strategies. In the first, the learner is assumed to test one strategy at a time, eliminating those that result in failure and retaining the one that results in success whether it be the first or the nth strategy tested. In the second, the subject selects from his store of strategies all of those that appear appropriate to the problem at hand. The testing of each strategy provides him with information that can then be used in determining the potential utility of other strategies. This strategy places a great deal of strain on the memory. If the effect of a given strategy at a given trial is forgotten the learner must start all over again. In the third strategy the learner proceeds in similar fashion except that the set of strategies is chosen at random and he attempts to narrow down the appropriate strategy within that sample. Such models assume the primary operation is that of selecting not of acquisition (i.e., conditioning, etc.). In a general way, this model parallels the one suggested by Bruner, *et al*.

We assume further that the human learner has definite preferences for which strategies he will use over others. The reason for these preferences may range from tendencies that are inherited, acquired from the culture, or acquired from personal experience. These tendencies for the use of given strategies are often called cognitive styles and constitute an important source of individual differences in learning whether Type I, II, or III.

Strategies and Cognitive Styles in Transformations

Cognitive style reflects pervasive features of individual differences in (a) general approaches to problems; (b) ways by which materials are organized, processed, or stored; and (c) general personality tendencies which indirectly affect transformations.

With regard to general approaches to problems it can be seen that strategies are employed in characteristic and consistent ways. Kagan (1965), for example, found that learners may be differentiated on the basis of impulsivity-reflectivity. Impulsive learners attempt to arrive at answers immediately without further efforts at checking their results. Reflective learners check all alternatives; they deliberate on the validity of an answer over another and view the problem from all perspectives before deciding on a solution.

By contrast, Witkin *et al*. (1962) have identified individual differences in field dependence. Learners who are field-dependent are easily distracted by irrelevant details in the situation to which they are attending. Field-independent learners, on the other hand, are able to "zero" in on one aspect of a problem with little interference from other situational elements.

Individual differences in ways of processing materials comprise the largest of the three categories. Some learners may find that they have difficulty in recalling material. They therefore depend on taking notes as direct copies of a lecture. Others may find they can store a great deal of material easily and readily. Accordingly, they may directly transform the material being presented. Distinctions between the two groups (i.e., between learners with "short" memories and those with "better" memories) may be made on the basis of measures of rote memory such as the digit span test or of short-term memory as in the task employed by the Petersons (1959).

An interesting finding from studies of paired-associate learning provides a particularly fine opportunity for illustrating how individual differences in preferences for one strategy over another might be related to treatment differences. Thus, a consistent finding is that high imagery of words used as the stimulus element in the pair is of greater importance in facilitating acquisition than high imagery of the response element (Paivio, 1963). However, in opposition to this finding is another consistent result related to meaningfulness. In this instance, response meaningfulness has proved to have considerably greater facilitating effects on acquisition of word-pairs than has stimulus meaningfulness (Underwood & Schulz, 1960).

High imagery of words, it would seem, is correlated with high certainty, thereby making words with this characteristic particularly advantageous to learning when in the stimulus position. The reason for this, however, is associated as much with a strategy as with other factors. On the other hand, meaningfulness involves a relationship between the material and the personal experience (cognitive structure) of the person doing the learning. The more meaningful the word, the more associates it has and therefore the easier it will be to hook-up the stimulus with it. On these grounds, it would be hypothesized that high-imagers, that is those who have a preference for using the imagery strategy would be at advantage over low-imagers in tasks that employed words with low rated imagery in the stimulus position. Conversely, learners with a well-developed cognitive structure (for example, high verbal ability, high RAT scorers, and so on) should have a particular advantage over those with a restricted cognitive structure (for example, low verbal ability) when words with low meaningfulness are employed in the response element.

Several studies illustrate the potential roles of individual differences in cognitive styles on the transformation of learning material and on the way in which materials are processed and finally presented for storage in memory. The remote-associates test provides a basis for differentiating among learners who are mediators and non-mediators. High scorers are those who can link several apparently unique and discrete words by some common bond. This measure appears to be related to the ability to make higher level transformations. Bruner and Tafjel (1961) suggest the possibility that some learners are broad categorizers and others are narrow categorizers. The former make larger categories encompassing more material, the latter form smaller, tighter categories which they change as the demands of the situation change. Holtzman and Gardner (1960) differentiated levelers from sharpeners to describe individual differences in the way materials were simplified for storage in memory. In a somewhat similar vein, other investigators (e.g., Vannoy, 1965; Munsinger & Kessen, 1964) have distinguished preferences for cognitive simplicity versus cognitive complexity.

The final large class of individual differences are the more or less permanent, enduring, personality behavioral tendencies. Manifest or trait anxiety is such a variable. Its effects, from several frameworks, are suggested to be: (a) a drive which interacts multiplicatively with learning to facilitate performance where single or correct responses are dominant but hindering learning when the correct behavior competes with an incorrect and more dominant behavior; (b) an interference with any learning when the learner is disposed to remove the pain of threat of anxiety rather than direct his energies toward solution of the problem; (c) facilitating when anxiety has been associated with task-relevant behaviors but debilitating when anxiety has been associated with task-irrelevant behaviors. Trait anxiety, as a personality variable, is to be clearly separated from temporary or situation specific anxiety sometimes referred to as state anxiety.

An individual difference variable, related to generalized personality tendencies, and which was employed frequently in the present program of research was the Dogmatism scale (Rokeach, 1960). High dogmatism (i.e., closed-minded persons) tends to be associated with dependence on an external authority; such persons tend to be source-oriented. Conversely, low dogmatism tends to be associated with determining the validity and reliability of a message regardless of the power, authority, or expertise of the communicator; i.e., open-minded persons (low dogmatics) are message-oriented. A similar view is held for individual differences in intolerance of ambiguity. The learner who is intolerant of ambiguity is similar to the high dogmatic; both want immediate answers and tend to work impulsively. Especially important, however, is the finding that intolerant individuals are impatient with conflicting evidence and tentative conclusions (Ausubel, 1968).

An interesting interaction between strategy preferences, reflected in dogmatism, and treatments was found in a study by Schultz and Di Vesta (1971, in press). The general rationale was that open-minded persons, as measured by Rokeach's (1960) Dogmatism scale, prefer to employ the strategy of examining the validity of the content of a message while closed-minded persons employ the strategy of depending on the source of a message particularly if that source manifests authority, power, or expertise. Within this framework, it was hypothesized that open-mindedness would facilitate problem-solving when incorrect alternative solutions were endorsed by a presumed expert but would hinder problem-solution when correct alternatives were endorsed. The reasoning behind this hypothesis was that careful scrutiny given the incorrect alternative would provide a basis for its early rejection; however, careful scrutiny given the correct alternative would delay its use with the consequence that more errors would be made or more solution time would be required. Conversely, it was hypothesized that closed-mindedness would facilitate problem-solving when correct alternatives were endorsed by an expert, since the correct alternative would be immediately accepted, while it would hinder problem-solving when the incorrect alternatives were endorsed since they too would be accepted immediately and without question. These hypotheses were supported by the results of the experiment thereby indicating that personality differences, because of their potential relationships to the strategies preferred by learners, may affect scanning, organization of materials, and other cognitive processes employed in transformation.

Some studies have made a distinction between external locus of control and internal locus of control (Rotter, 1966). Typically, there is no difference in performance between the two groups under circumstances where there is an emphasis on success, i.e., where there is only reward for correct responses and no punishment for incorrect responses. However, where there is an emphasis on failure, i.e., where the learner's shortcomings are pointed out, where he is punished for incorrect responses, or where there are penalties for errors the learner characterized by internal locus of control has the advantage; he tends to be self-sufficient. On the other hand, the one with external locus of control is less secure and gains his confidence from praise and other indications of success provided by other persons.

A particularly useful example of cognitive style as an habitual mode of responding or as a preference for a given strategy for Type III learning is the distinction between hypothesis spewers and conservative strategists (Sanders, Di Vesta & Gray, 1971, in press). The former are hypothesized to randomly formulate and test hypotheses. The latter (i.e., the conservative strategists) on the other hand, reserve judgment in an effort to infer common properties of concept instances or in an effort to select hypotheses based on their best judgment. From this framework Kurtz and Hovland (1956) inferred that "among Ss who actively attempt to abstract the common properties of several instances before formulating a hypothesis, the unmixed order of presentation (blocked) would be relatively easier than the mixed order [of presentation of exemplars of several concepts to be learned together], but among Ss choosing hypotheses by trial and error the difference might be considerably reduced." Sechrest and Wallace (1962) also offered the conjecture that "The Ss who can maintain some independence of a random array during solution might be more efficient [when the array is randomly mixed] than the subjects who use the array to shape and formulate hypotheses as well." On the basis of their conclusions it can be reasoned that the conservative strategist will learn more efficiently than the hypothesis spewer from blocked presentations of concept instances; while there will be little difference in learning efficiency, or even a possible advantage for the hypothesis spewer, when random presentations are used. In a transfer task the conservative strategist will suffer more loss going from blocked presentation on learning trials to random presentation on transfer trials than he would going from blocked to blocked presentation, and, conversely, hypothesis spewers will suffer more loss from change from random to blocked than from blocked to blocked presentations. In their experiment designed to test this hypothesis, Sanders, Di Vesta & Gray (1971) found one of three measures of individual differences in strategies interacted significantly ($p < .05$) with presentation conditions. This result implied that learners who randomly formulate hypotheses are not as influenced by presentation conditions as those who prefer (or tend) to adopt a systematic strategy.

Summary

Learning was viewed in this chapter as a cognitive activity involving a hierarchy of transformational processes. The parallel instructional activity requires that instructors should establish situations for allowing shared discovery of structure and the building of tools for structuring and restructuring.

Transformation is initiated with the processing of stimulus input through selective attention. The initial outcome, itself a transformation, is a pattern or percept which is labeled by verbal means for storage.

In order to account for higher forms of cognitive behavior such as conceptualizing, problem-solving and creativity, three levels of transformation of the initial input were hypothesized. Each level was assumed to be related to the previous one; that is, the levels were assumed to be hierarchically arranged. However, they were also assumed to be distinctive in their behavioral manifestations, that is, they were assumed to represent independent stages in cognitive processing as well as resulting in structurally different behaviors.

The first kind of transformation was labeled Type I as a general term for a primary or elementary form of processing. Its unique characteristic is that storage is primarily 1:1 with experience. There is very little, if any, meaningful (e.g., semantic) coding although learners might impose artificial codes on the material in attempts to facilitate retention. The second kind of transformation (Type II) emphasizes processing by abstraction in which meaningful patterns are extracted from experience through sophisiticated coding strategies. The third type of transformations (Type III), called inferential, emphasizes the formation of unique combinations of knowledge into complex patterns of broad generality. Type III transformations allow for the development of new knowledge by permitting logical deductions, derivations, inferences, solutions and the like.

The relationships between the types of transformations and memory were discussed. In addition, each type appears to be related differentially to the kind of individual difference variable that may influence its use. The theory presented here, though in need of further development, appears to offer opportunities for developing such testable hypotheses as those involved in the assumption that transformations are hierarchically arranged. They also delineate in clear fashion the kind of measures and dependent variables that must be employed with different objectives whether in experimental or instructional settings.

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Chapter Five

Student Instrumental Activities and Instructional Strategies

Paul D. Weener

Research on instruction previous to 1965 tended to emphasize a comparison of the effects of different instructional methods on specified learning outcomes. The disregard for the student activities which intervened between the instructional variables and the learning outcomes was undoubtedly a reflection of the then dominant behavioristic emphasis in the study of human behavior. The instructional events, whether they be teaching styles, modes of verbal interaction, or instructional materials were viewed as the stimuli and the student attitude and learning behaviors as responses. Much of the early instructional research was an attempt to describe the functional relationships between the characteristics of the external instructional stimuli and the observable learning responses. Since 1965 one of the dominant themes in instructional research has been the study of the activities engaged in by students which result from instruction.

Research on student activities resulting from instruction seeks answers to questions such as, "(1) What is it that students do while the instructor is instructing? (2) What activities do students engage in between the time of the onset of instruction and the elicitation of criterial performance, and how do these activities affect performance? (3) What can the instructor do to manipulate such behaviors to maximize performance?" (See Chapter One.) We have called a class of student behaviors which intervene between instruction and criterion performance, student instrumental activities. Instrumental activities are those activities which are learner initiated or directed, and mediate between the instructional demands and the learning outcomes. Instrumental activities are influenced and directed by motivational factors, goal expectancies, task characteristics and perceived task demands, and they in turn influence transformational processes and learning outcomes.

The primary function of instrumental activities is in mediating between the student's perception of the instructional goals and the learning outcomes. Given this orientation, not all activities which intervene between task presentation and learning outcomes can be called instrumental activities. The activities must have some logical or empirical relationship to the task requirements and the eventual learning outcomes. The learner may intentionally involve himself in activities which he perceives to be instrumental in achieving the instructional goal. He may also incidentally engage in activities which he does not perceive as being related to the instructional goals, but these activities could be empirically demonstrated to be related to learning outcomes. Looking out of the window, doodling, sleeping, talking to someone about the past week's football game would not be considered instrumental activities in most instructional settings because they do not bear any logical or empirical relationship to the instructional goals. In short, instrumental activities are directed toward the instructional materials and/or are demonstrably related to relevant learning outcomes.

Student activities which fit the definition of instrumental activities are both overt and covert. Covert forms of instrumental activities include silent rehearsal, evoking images, constructing mnemonics on other verbal associates. The most common forms of overt instrumental activities are note-taking and verbalizing. The focus in this chapter will be on the overt forms of instrumental activities, specifically, note-taking and verbalizing. The primary purpose of this restriction is to delineate between instrumental activities and transformational processes which are treated in Chapter Four. Furthermore, note-taking and verbalizing are observable activities common to all instructional activities, and easily recognizable by educators as important elements in any instructional setting.

The purpose of this chapter can best be expressed in terms of three questions regarding note-taking and verbalizing. These questions are (1) How is the activity stimulated? or relatedly, How can this activity be manipulated in an instructional setting? (2) What are the effects and learning outcomes of this activity? (3) What are the implications for instructional strategies? or put another way, When and for whom is this activity instrumental in accomplishing the instructional goals? In answering these questions, available research will be reviewed, relevant theoretical positions analyzed, and needed research suggested.

The recent writings of Anderson (1970), Frase (1970) and Rothkopf (1968, 1970) are characterized by an emphasis on student activities during learning. These writers have used a number of concepts which are closely related to the concept of instrumental activity. Anderson stated "that the activities the student engages in when confronted with instructional tasks are of crucial importance in determining what he will learn" (p. 349). He emphasized the role of attentional and mediating processes. Attention, according to Anderson, involves the orientation of the sensory perceptor to the instructional stimuli and the encoding of the stimuli. The latter step transforms the nominal stimuli into the effective stimulus. That is, the potential stimuli presented by the instructor becomes actual stimuli for the student.

Selective attention and the accompanying search behavior constitute important aspects of the orientation part of attention. The control of the students' orientation behaviors in instructional settings is carried out by various cueing and prompting techniques. Underlining and italicizing are two straightforward ways of modifying the student's attention while studying written materials. The intonation contours of auditorily presented materials involving differential stress and pauses accomplishes a similar modification of students' orientation while listening. Requiring an active written or oral response from the student causes the student to focus his attention on particular aspects of the presented stimuli. Questioning procedures before, during, and after the presentation of written materials have also been shown to shape the orientation behaviors of learners, and consequently influence what and how much is learned. (See Chapter Three.)

Underlining, italicizing, and using intonation patterns are direct means available to the instructor to modify the attentional processes of the learner. Questioning and other procedures which call for an active learner response are more indirect means of shaping the attentional and transformational processes of the learner.

Control of attention is only the first stage of the process required to assure learning, according to Anderson. Subsequent learner activities in the mediating process include "translating it [the stimulus] into internal speech, evoking images for the things and events named by the words, and conceiving relationships among the imagined things or events" (p. 363). These latter two activities Anderson has labeled "cue encoding" and "associative linkage".

Ausubel described this kind of learner activity as the incorporation of new knowledge into existing cognitive structure. In this stage, the learner handles the new material mentally and ties it into existing cognitive structure through the mental activities of internal speech, imaging, and associating.

Rothkopf's writings have stressed the role of intervening student activities. In an early writing, he referred to "inspection behavior" as "everything *S* does when exposed to the stimulus material, whether these activities are conducive to learning or not" (1963, p. 124). His later writings have stressed the concept of mathemagenic behavior (1968, 1970) defined as learner "activities which give birth to learning ... They include such activities as reading, asking questions, inspecting an object, keeping the face oriented toward the teacher and mentally reviewing a recently seen motion picture." Mathemagenic behaviors have the potential function of translation, segmentation, and processing (Rothkopf, 1968). These three functions can be thought of as being hierarchically and sequentially related. *Translation* involves the taking of the written stimulus and translating it into a string of sounds or their subvocal representatives. This step can be viewed as a surface phenomenon, a necessary prerequisite to comprehension or understanding. *Segmentation* involves breaking the message into units on the basis of syntactic or semantic features. The function of this process is to reduce the material to conceptual units which can facilitate the processing demands. *Processing* involves those activities which are commonly called thinking, including problem solving, review, and the formation of higher level organizational units.

Rothkopf has repeatedly emphasized that the end goal of instruction can be thought of as the stimulation of positive mathemagenic behaviors. Mathemagenic behaviors have an adaptive character which can be shaped by instructional events. Rothkopf's research has focused on the role of written questions and their effectiveness in shaping student behavior while studying and their influence on learning outcomes. The role of questioning has subsequently become an important topic in research on instruction.

Note-Taking

Note-taking is one of the most encouraged and common activities that students engage in during the instructional process. The beneficial effects of note-taking seem intuitive and follow from some generally accepted principles of learning. First, the note-taker is active. On the basis of the argument that the active learner learns more than the passive learner one would hypothesize that note-taking would result in greater learning. Second, note-taking gives the learner a chance to reorganize, elaborate, and associate so as to better assimilate the new material into cognitive structure. The "cue encoding" and "associative linking" processes described by Anderson would be an expected outcome of note-taking activities. In short, note-taking can be seen as a process whereby the instructional stimuli are transformed and recoded into mental units which make the stimuli more recallable than if the learner had not engaged in note-taking.

It can also be argued that note-taking may inhibit rather than facilitate learning. The overt response of writing may interfere with the receiving of new information. The note- taker may be cognitively passive while he is serving merely as a receiver-transmitter of the message. Crawford (1925a) summarized the position of instructors who emphasized these negative aspects of note-taking. "Some [instructors] ... discourage note-taking, and still others forbid it, giving as a reason for doing so their desire that the students get their ideas, rather than their words. There is in many quarters a conviction that undivided attention to the lecture as it is delivered is superior to writing notes and later studying them" (p. 282).

The research literature on the effects of note-taking indicates a very mixed picture. There are some consistencies, but because the research has lacked any orienting foci or common porcedures many questions remain to be answered.

There are three different approaches to the study of note-taking reflected in the literature. One approach is to study how note-taking varies as the result of different instructional demands. The other two methods of study use note-taking as an independent variable to study its effect on some learning criteria. One of these approaches has been to obtain correlations between the contents of student's notes and the contents of that which is remembered in a subsequent learning task. The third type of study investigated the effects on learning of note-taking versus no note-taking conditions.

The stimulation of note-taking. How do various instructional events influence note-taking behavior? What conditions stimulate and what conditions inhibit note-taking? Are the type of notes taken influenced by the type of test anticipated or the amount of time anticipated between the note-taking and the recall? These questions point out some of the factors which could be studied to determine the instructional events which influence note-taking behavior.

Two recent studies provided some serendipitous information on note-taking behavior. Hakstian (1971) studied the effects of type of examination anticipated on test preparation and performance. In the first of two experiments, no significant correlations were found between "degree of making notes" and performance on an essay or objective test given as a course midterm, or on an objective retention test given two weeks later. The experiment was carried out in a single class, and test expectation was created by differential test information presented in a handout on the first day of class. One weakness of the study is that the experimental effects could easily be contaminated by intra-group communication. Since all subjects sat side by side in the same classroom, certain group norms regarding classroom note-taking activities could easily be established and wash out the effects of the treatment. Another weakness of this experiment was that there were only 12 subjects in each experimental group with a resulting large sampling error for the obtained statistics.

The second experiment reported by Hakstian was carried out to study the same test anticipation effects. In this experiment there was again no significant correlations between type of test anticipated and the "extent of taking notes and summaries." But significant correlations were found between "extent of underlining and highlighting" and performance on the objective test and the essay test. An analysis of reported means indicated that there was very little note-taking activity in this experiment. The subjects averaged about 15 *words* of notes in the approximately 50 minutes that they studied the material. An average of 65 *lines* of text were underlined. The findings on underlining can be interpreted with more confidence than the findings on note-taking because the former is based on a much larger sample of behavior than the latter.

Weener (1971) carried out a study which investigated the effects of anticipated recall mode and recall interval expectancies on note-taking and recall. The three different anticipated recall modes - multiple-choice test, essay, and verbal presentation - did not produce significant differences in amount of notes taken. The group which epxected a test immediately after the instructional presentation took about half as many notes as the group which expected a test one week later, even though everyone was told that they would not be permitted to use their notes during the test. On an essay test, the immediate expectancy group performed significantly better than the delayed expectancy group. There were no significant differences between the different expectancy groups when a multiple-choice test was used as the dependent measure. This leads to the interesting conclusion that the groups which took more notes performed less well on the essay test than the groups which took fewer notes. This was true both for an immediate and one-week delayed essay test. An explanation of these findings is that the delayed test expectancy leads to external storage behavior such as note-taking rather than active internal transformational processes, and that an immediate test expectancy leads to less note-taking but more active internal transformational activities. External storage behaviors such as note-taking are most likely not an efficient information processing strategy when the externally stored information will not be available to facilitate recall, as was the case in this experiment.

The effects of note-taking: Correlation studies. Crawford's (1925a) study is a good example of the correlational approach to the study of note-taking. He delivered lectures on which students took notes in their usual manner. He then gave quizzes on the lectures and collected the notes which the students had taken. The notes and quizzes were then scored using a point-by-point outline of the lecture as the scoring key. The scores on the notes were then correlated with the scores on the quizzes. Seven different classes composed of 211 undergraduate and graduate students followed this procedure. Six of the classes were notified of the quizzes and reviewed for them, but the seventh class made no special preparation. The time interval between the lecture and the quiz varied from 12 to 35 days.

A median correlation of .50 with a range of .36 to .66 was found between the total points which were correct in notes and the total points correct on quiz papers. Partialling out intelligence scores of the students influenced the correlations only slightly.

Crawford also did a point-by-point comparison of points mentioned in the paper and in the notes for all of the students. Of 2250 points which were classified as wrong or omitted in notes, 1932, or 86% of them, were found to be wrong or omitted from the quiz papers and only 14% were scored as "right or vague" in quiz papers. Of the 2501 points which were classified as "right or vague" in notes, 51% were "right or vague" on the quiz also and 49% were considered "wrong or omitted" on the quiz. From this finding Crawford concluded, "It is apparent, therefore, that taking notes on a point does not guarantee its being recalled at the time of the quiz, but that failure to take note of it very greatly decreases its chances of being recalled" (p. 289).

Howe (1970) reported a similar relationship between the content of notes and that which is recalled at a later time. The subjects were read a short prose passage, instructed to take notes, and one week later they returned to write as much as they could recall of the prose passage. Howe then compared items in the notes with items on the recall test. The mean probability that a subject would recall an item that appeared in his written notes was .34 whereas the probability of recalling an item that was not in the notes was .047. Both of these studies indicated that if a message had not been written down in a student's notes the probability of its being recalled at a later time was very small.

McClendon (1958) approached the problem in a somewhat different manner by dividing 687 college freshmen into four groups based on an analysis of the type of notes they took: (1) regular note-taking (2) note-taking on main points only (3) note-taking on detail, and (4) no note-taking. Comprehension tests were given immediately following the lecture and also five weeks later. There were no significant differences among the four treatments for either the immediate or delayed test performance.

The effects of note-taking: Notes versus no notes. In a follow-up study to his correlational study, Crawford (1925b) reported the results of seven experiments which investigated the effects of notes versus no notes, and review versus no review in three different types of classroom settings. In all 7 experiments, essay tests were given and in 4 of the experiments a true-false test was also given. Crawford succinctly summarizes the findings:

"1. When results are measured by a general quiz of the traditional type immediately after the lecture, the note-takers show a fairly high degree of superiority over those who do not take notes.

2. When results are measured by the general quiz after a period of days or weeks and after there has been opportunity to review the notes which were previously taken, the note-takers show marked superiority over those who do not take notes.

3. When results are measured by the true-false test immediately after the lecture, the note-takers are slightly inferior to the listeners.

4. When results are measured by the true-false test after a period of days or weeks, involving the opportunity to review the notes, the note-takers are at an advantage, but not so great as in the case of the general quiz" (p. 386).

There are two methodological weaknesses in the Crawford experiments which detract from the conclusions. In the notes versus no notes experiments intact classes were divided into two subgroups. On one day, subgroup A was told to take notes and subgroup B was told to listen and on the next day group A listened and group B took notes. This method could create something like a Hawthorne effect which could result in the note-taking subgroup being more motivated and paying more attention than the listening subgroup. The second weakness concerned the review procedure used. The review-no review condition was not independent of the notes-no notes condition. The subjects used in the review-no review experiments had been previously exposed to both a notes and a no notes lecture condition as described above. The review period was used to go over the notes of the lecture in which they had been permitted to take notes. The comparison was between a notes plus review condition and a listening only condition. There were no comparisons of notes plus review with a notes only condition or a listening plus review with a note-taking plus review condition, both of which seem to be more crucial experimental comparisons than the comparison which Crawford made.

A study by Di Vesta and Gray (1971) did investigate the effects of notes versus no notes and rehearsal versus no rehearsal in an experiment which had all four possible combinations of the notes and rehearsal factors. In the no notes condition subjects were told to listen to the verbally presented message; in the rehearsal condition subjects were given five minutes to mentally review or to review their notes in the no notes and notes condition, respectively. In the no rehearsal condition the subjects were given an unrelated task to perform. The results showed that the main effect of note-taking was significant for number of ideas generated on a recall task and for total score on an 8-item multiple-choice test. The group that rehearsed generated significantly more ideas on the recall test, but did not perform significantly better on the multiple-choice test. The interaction between the rehearsal factor and the note-taking factor was not significant although the difference between the note-taking and no note-taking condition was less in the rehearsal condition than in the no rehearsal condition. These findings illustrate the points made with reference to the interpretation of Crawford's findings regarding the effects of rehearsal. There was no group in the Crawford study which did not take notes but which did rehearse before the test. From the Di Vesta and Gray findings, the rehearsal facilitated both those who had taken notes and those who had not. Thus Crawford's statement that the effects of note-taking increased when the opportunity to review the notes was given disregards the fact that the subjects who did not take notes might have benefited equally if the opportunity for review had been given them as well.

Eisner and Rhode (1959) did a study on note-taking either during or after the lecture. The subjects who took notes on the 30-minute lecture were given 15 minutes to study their notes after the lecture; the subjects who did not take notes were asked to "jot down any notes you wish" during the 15 minutes following the lecture. All groups were given a 50-item true-false test and an essay question two days later and a 50-item true-false test again three weeks later. No significant differences in performance were found for any of the comparisons between the two groups. For the sake of the present consideration, it would have been very informative if a third group had also been used which did not take notes but used the 15 minutes for mental review. The group that took notes after the lecture is of course different than the "no notes" conditions discussed in the previous two experiments. The anticipation of taking notes in the "notes after" condition might have resulted in some of the same desirable mathemagenic activities as taking notes during the lecture and thus resulted in no differences.

Significant dimensions in the study of note-taking. At least four significant dimensions of instructional settings emerge in analyzing the previous research on note-taking behavior. They can be expressed as questions which call attention to aspects of the instructional setting which seem to be important in determining the effects of note-taking. First, is the learning performance immediate or delayed in relation to the note-taking activity? Second, are the notes taken available or not available for review purposes? Third, is a recall or recognition measure of learning used? Fourth, is the stimulus material visually or auditorily presented? The effects of note-taking along any of these dimensions has not been adequately enough researched to provide clear answers. The first and second questions have not been dealt with directly in any of the reported research. All studies (Crawford, 1925b, Di Vesta and Gray, 1971, & Weener, 1971) which made a recognition-recall distinction indicated that the beneficial effects of note-taking are greater for recall than recognition learning. All of the reported studies except Weener's (1971) used auditory stimulus materials. Weener's study also showed the most negative results regarding the effects of note-taking, suggesting that the effects of note-taking may be more beneficial when the instructional material is spoken rather than written. None of the four questions have begun to be adequately answered by the available research. A systematic research program using the proposed questions to define experimental factors would contribute much to an understanding of the role of note-taking activities in instruction.

Instructional implications of note-taking research. The role that note-taking plays in the storage and retrieval of information is probably dependent on the characteristics of the instructional setting and individual difference characteristics. Note-taking can be described as the product of transformational processes. While listening or reading, the student transforms the presented messages in ways which can be described as associational, conceptual, and inferential transformations (See Table 1, Chapter Four). Notes can be regarded as the recording of the products of these transformational processes. Notes may represent verbatim copying (associational transformation), or chunking, coding, and organizing of the message (conceptual transformations), or rules and inferences (inferential transformations). The role that note-taking plays in the storage-retrieval process depends to a great extent on the type of transformation which the notes represent.

In addition to being a reflection of the cognitive processes which the learner engages in, notes are also an external storage. In this sense they can serve the function of a mnemonic device, an aid to the recall of information and the structure of that information. A question which needs empirical research and is also theoretically important is, to what extent is this external store dimension of note-taking important in the storage-retrieval process? Perhaps note-taking facilitates learning because it makes more permanent the product of a particular transformational process. The time needed to write an idea down may permit a fixing or consolidation of that particular idea which makes it more permanent and more easily recognized or recalled at a later time. If one emphasizes the external store characteristic of notes, then what happens at the time of the note-taking is not as important as the fact that an external non-decaying trace of the message is available. Until more research is done varying the interval between note-taking and information retrieval along with review-no review conditions, this question cannot begin to be resolved.

The claim that note-taking can interfere with learning probably depends on the instructional setting and individual characteristics of the learner. If the student engages in note- taking as a verbatim record of the presented message, the note-taking very likely interferes with higher-level transformational processes. It might be said that in this situation the learner is not "thinking" but merely serving as a recorder-transmitter of the presented message. If only recognition learning is measured, this type of note-taking may not have interfering effects, but if learning related to the higher-level transformational processes is required, this type of note-taking would very likely have detrimental effects.

Although we have speculated at several times that individual differences influence the effects of note-taking, no empirical evidence is available to shed light on this issue. Memory variables, such as short-term memory and the resistance of memory to interpolated material, would be likely individual difference variables related to the effects of note-taking. Social desirability might well effect the number of notes taken in instructional and experimental settings with a person high on the social desirability scale producing more notes than a student low on this scale. Authoritarianism could influence the number of notes take in a similar manner, particularly if the source of the presented message is viewed as an authority. There may also be an individual difference variable directly related to the "memory aid" function of notes. To some people with good unaided memories the effects of notes may be minimal, but to those who depend a great deal on "memory aids" the effects of notes may be substantial. But until further research is carried out the effects of individual differences on the role of note-taking can only be inferred from theoretical speculations relating the functions of note-taking to the definitions of known individual differences.

Student Verbalization in Instructional Settings

Two distinctive approaches can be taken to the study of the role of student verbalization in instructional settings. The first is pedagogical involving a comparative study of the effects of instructional methods which have varying degrees of student verbalization, primarily, recitation and discussion methods. The second approach is more theoretical and involves a study of the effects of learner verbalization on the psychological processes of problem solving, concept formation, and memory. The primary focus of the following section will be on the question, How does overt student verbalization of instructional stimuli influence learning outcomes?

A review of past work in this area reveals a rather pervasive conviction that the student's task-related verbal participation should facilitate learning of the presented instructional material. A number of reasons can be given to explain the proposed beneficial effects of overt verbalization. The first two reasons are similar to those used to explain the effects of note-taking.

1. Student verbalization induces active associational and coding processes which facilitate learning. These are the processes of "making meaningful," of "putting into one's own words," of "assimilating into cognitive structure." These processes include the substitution of familiar words and phrases for unfamiliar words and phrases, the application of some meaningful mnemonic to remember the overall structure of an instructional presentation and the transformation of the stimulus material into a set of symbols which can be stored and processed effectively. If classroom verbalization produces these activities, then one would argue that student verbal presentations should facilitate

learning as compared to instructional settings in which the student does not have the opportunity to actively verbalize.

2. Student verbalization increases arousal and motivation. From this viewpoint, the beneficial effects of classroom verbal participation are increased attention and mental activity which in turn results in greater learning. Due to the curvilinear relationship of arousal to learning, the beneficial effects of increasing arousal through student verbalization would be restricted to situations which initially produce low arousal levels. Most formal instructional settings are characterized by relatively low levels of student arousal and hence an increase in arousal resulting from verbalization would have positive effects on learning.

3. The beneficial effects of verbalization are due to the effects of the motor activity which accompanies verbalization. An assumption of this position is that overt verbalization provides an additional memory cue as compared to purely covert processes, like thinking. The verbalized response has two additional dimensions -- the proprioceptive feedback from the speech muscles plus the auditory input -- whereas the unverbalized response has only the mental response.

4. When the instructional materials are only presented visually, then verbalization can have the beneficial effect of providing an additional input channel. It seems logical that a two modality input would be remembered longer than a one modality input. Or, looking at it in a slightly different way, the verbalization of a visual presentation can serve as an immediate review of the visually presented material.

5. The advantage of verbalizing visually presented material may be that auditory storage is better than visual storage. From this

viewpoint, verbalization transforms the more poorly remembered visual message into the better remembered auditory message.

All of the above five explanations could be used to support a position which promotes verbalization in instructional settings. Perhaps the most intuitive argument against student verbalization in instructional settings is that the verbalization can interfere with incoming stimuli. While a person is talking he can receive only a limited amount of information. One could follow this line of reasoning to conclude that the more time one spends verbalizing the less time one will have available to receive or rehearse new information. Thus the verbalization may prevent or interfere with the reception of new information.

The remainder of this chapter will deal with (1) an evaluation of studies which have investigated the effects of different instructional methods which utilize verbalization, (2) a review and evaluation of the theoretical research regarding the effects of verbalization on learning, and (3) the instructional implications of available evidence about verbalization in instructional settings.

Verbalization in instructional settings. The effects of verbalization in classroom settings is usually confounded by a number of extraneous variables. The instructional methods which use student verbalization as an important component differ in ways other than the amount of student verbalization which occurs. Instructional techniques such as recitation and discussion usually involve student-teacher verbal interaction; team learning and other techniques which use small groups involve pupil-pupil verbal interaction. A third type of verbalization - verbalization to one's self - is possible but is seldom employed in instructional strategies. Recitation, discussion, and team learning all involve social variables in addition to the verbalization variable. As a result the research which has been done on the effects of these instructional methods does not provide a clear indication of the effects of verbalization alone.

The role of verbalization in classroom learning also is a factor in the perennial issues of group versus individual performance, teacher-centered versus learner-centered instructional strategies, and the lecture method versus the discussion method. Review of the research literature on each of these issues has revealed generally inconsistent results. One of the reasons for the inconsistent results is that each method consists of a number of interacting variables. These variables each probably have a consistent relationship with the learning criteria used, but when allowed to vary in uncontrolled ways within a general method the effects of the variables sometimes cancel each other out and at other times reinforce each other to produce "method" effects.

Learner-centered instruction and discussion methods are methods which would include much more student verbalization than teacher-centered and lecture methods, respectively. But reviews of the relevant literature by Lorge, Fox, Davitz, and Brenner (1958) and McKeachie (1962) have failed to show any clear benefit for the method involving more student verbalization. In a more controlled laboratory setting, Weener (1970) attempted to demonstrate the beneficial effects of verbalization by creating four study conditions defined in terms of varying opportunities to verbally summarize the presented instructional materials. The groups which had opportunity to verbally summarize the contents of an instructional film did not perform significantly different on any of the criterion measures than the group which studied alone. Results were the same on a multiple-choice test and an essay test which were administered as criterion tests immediately after the "class" period and again one week later.

Guetzkow, Kelly, and McKeachie (1954) reported a study which involved 865 students in an elementary psychology course. The study contrasted recitation-drill, group-discussion, and tutorial-study. Although the methods did not contrast strongly in the amount of student verbalization possible, the type of verbalization encouraged was quite different in the three methods. The results were for the most part insignificant and were surprisingly consistent across eight different criterion measures. These kinds of inconsistent results have led many researchers to conclude that a more analytic, theoretical approach to instructional strategies is required.

Theoretical accounts of the function of verbalization. A number of more controlled experimental studies have shown clear benefits from verbalization for a variety of learning criteria. Hardyck and Petrinovich (1970) concluded upon reviewing some of this literature that "learning is facilitated by an increase in the amount of vocal activity" (p. 647). Kurtz and Hovland (1953) demonstrated that *Ss* who verbalized the names of presented stimulus objects were able to correctly identify more of the objects on a recognition test administered one week later. Rosenbaum (1962) modified the Kurtz and Hovland procedure and introduced two other verbalization groups, one in which a peer and another in which an "expert" verbalized the name of the presented object. In this experiment, the verbalization conditions produced better recognition scores than the no verbalization condition, but the vicarious verbalization conditions produced as good recognition as the self-verbalization condition. Murray (1965) showed that "if subjects voiced a list of eight consonants, immediate recall of the consonants was superior to that obtained if they whispered them; whispered lists were better recalled than mouthed lists; and mouthed lists were better recalled than silently read lists," (Murray, 1966, p. 9). In a subsequent study, Murray (1966) demonstrated that the beneficial effects of voicing the lists was most marked at fast rates of presentation.

In a discrimination learning task Carmean and Weir (1967) found that subjects who verbalized the correct response in a two-choice task showed more rapid learning than a control group which did not verbalize and four other groups which verbalized the incorrect response, their chosen response, both responses, or a randomly selected response respectively. The results of studies like those cited do seem to warrant the conclusion of Hardyck and Petrinovich that learning is facilitated by an increase in vocal activity.

The experimental studies of the effects of verbalization do leave a number of theoretical questions unanswered. Verbalization produces auditory feedback as well as a muscle response with accompanying proprioceptive feedback to the central nervous system. Research has been conducted to determine which of these factors is instrumental in determining the beneficial effects of verbalization. The Rosenbaum study would seem to indicate that the actual articulation of the response was not important and that the auditory feedback was the facilitating effect. But those who have studied the subvocal activity of the speech musculature during language tasks would argue that a muscle response does accompany many tasks in which no audible vocalization occurs. McGuigan (1970) concluded that "the covert oral response facilitates the reception of external language stimuli and the internal processing of the information. Physiological considerations indicate complex and rapid feedback loops between speech regions of the brain and the speech musculature. These loops may function in the process of internal communication" (p. 309). Almost all of the research on subvocalization has employed electromyography to detect the presence of responses of the speech musculature, particularly the larynx, lips, and tongue.

Hardyck and Petrinovich (1970) report some empirical work and set forth a theoretical interpretation regarding the function of the muscle activity which accompanies speech or silent language tasks. Using reading materials at two levels of difficulty, they found that more subvocal chinlip and laryngeal activity accompanied the difficult reading passage than the easy passage. They contended that the auditory-proprioceptive consequences of verbalization provide "the most stable mediator in the associative learning of the arbitrary set of symbols the organism encounters when learning to read." Gradually the motor components are eliminated and replaced by "unidentified neural analogues." But "the audditory-proprioceptive stimulus complex may be reactivated when a high degree of redundancy of stimulus input is needed" (p. 651). In other words the more the speech musculature and vocalizers are activated the more sources of redundant cues become available for processing. This explains the common phenomenon of people rereading a difficult passage aloud or silently mouthing the words. The auditory and proprioceptive stimuli which accompany verbalization seem to be available sources of redundancy which can be used to reduce the difficulty level of ta task and increase comprehension. The relative function of the auditory versus the proprioceptive feedback is difficult to assess because of the difficulty of observing and quantifying the muscle responses which accompany varying degrees of overt and covert verbalization.

The above studied dealt with verbalization only in terms of vocalizing or articulating some presented stimuli. In most instructional settings student verbalization involves constructing responses which are assumed to involve mediational and transformational activities. As stated previously, it seems to be a common conviction that "putting things into your own words" facilitates learning. But the various studies on instructional methods which encouraged the verbal activity of paraphrasing and reorganization have not demonstrated consistently superior performance as compared to those conditions which involved silent study or listening.

In laboratory studies of verbal learning, the value of verbal mediation has been repeatedly demonstrated (Paivio, 1969; Yuille & Paivio, 1967). Subjects who are given instructions to think of or write a phrase or sentence which mediates the stimulus and response in a paired-associate task will learn better than those who do not engage in these mediational activities. This kind of evidence is a step toward explaining the facilitative effects of verbalization in terms of the active associational and coding processes which are induced.

The arousal effects of direct verbal participation can be inferred from a study by Travers, Van Wagenen, Haygood, & McCormick (1964). Subjects learned the English equivalents to German words under a direct verbal participation method and an observation method. Four students out of eight in each group were called on to respond so that each one responded to one out of the four presentations, while the other four students observed and listened to the interaction. The students who actively participated recalled consistently more than the non-participating subjects on both the words which they responded to as well as on the three-fourths of the words for which they only observed. Since the verbalizing subjects remembered more of the words which they did not respond to than the subjects who just observed, it can be argued that the beneficial effects are not due just to the effect of overtly responding. Travers et al., concluded, "The data suggest the interpretation that the direct interaction procedure raises the level of arousal of the direct subjects which, in turn, influences acquisition on the items which they learn by observation" (p. 173).

Another factor influencing the effects of verbalization is that the auditory trace which results from verbalization has different characteristics than the visual trace resulting from visual input alone. Conrad and Hull (1968) and Crowder (1970) have investigated this difference using serial learning tasks to demonstrate that the shape of the recall curve is different for visual versus auditory input and active vocalization versus passive vocalization, respectively. The implications of this for instructional strategy are not specific, but it does imply that the instructional strategists should not assume that the learning effects will be the same regardless of input mode. Crowder also points out that self-verbalization can be interfering when rehearsal is an important learning activity because the verbalization of the stimulus materials can interfere with rehearsal activities, and presumably, other thinking activities as well.

Instructional implications. Recitation has persisted as an instructional activity (Hoetker and Ahlbrand, 1969) even though the research literature has not demonstrated the consistent superiority of this form of overt student verbalization as compared to more covert forms of student study activity. Nor has anyone empirically distinguished between the situations under which verbalization or recitation might contribute to or interfere with new learning. However, there are theoretical principles which indicate the conditions under which verbalization might be used effectively. The type of research done on this issue does not warrant making prescriptive statements about when and when not to utilize student verbalization in an instructional strategy. But some testable hypothesis can be deduced from this literature.

First, when students are presented difficult reading material or other verbal material, verbalization can be valuable in the early stages of learning to introduce redundant cues and additional coding dimensions. When material is less difficult or after it has become better learned, the verbalization effects will probably be less positive and perhaps even interfering. Perhaps the most consistent findings in the research on verbalization would support its use in the learning of verbal associations. The most obvious applications would seem to be in the learning of English-foreign word equivalents, multiplication tables, and object-name associations. The verbalization of already learned pairs is probably less important than the verbalization of pairs to be learned. When wrong responses are anticipated or produced, verbalization of the correct response or both the stimulus and the response should increase learning rate.

Second, the powerful effects of verbal mediators in paired-associate and other verbal learning tasks (Bower, 1970) would imply that many instructional settings could profit from verbal mediation activities. Students should be encouraged to provide verbal links among disparate facts and principles. The subjective organization of instructional material may well facilitate the recallability of the individual components, but may also lead to useful and creative new organizations of the subject matter.

Third, when relatively low arousal levels exist in an instructional setting, the initiation of student verbal participation can raise arousal levels. However, because of the complex relationship between arousal level, task difficulty, and learning rate, the stimulation of arousal in a classroom setting must take into consideration the type of learning task (See Zajonc, 1966).

Summary

Instrumental activities are defined as those student activities which occur between task presentation and criterion learning performance and have some bearing on the relationship of the task requirements to the learning outcomes. This chapter investigated the common instrumental activities of note-taking and verbalization and their influence on learning outcomes. The study of instrumental activities is closely related to other recent work on student activities, such as, Anderson's research on attentional and mediational processes, Rothkopf's writings on inspection behavior and mathemagenic behavior, and Ausubel's emphasis on the importance of what the learner brings to the instructional setting.

With few exceptions, eudcators and researchers have looked on note-taking as a facilitative activity in most instructional settings. The scant research available on the conditions which stimulate or inhibit note-taking have indicated no relationship between the type of test anticipated and the amount of notes taken. The length of time between task presentation and learning performance does seem to be an important determinant of the amount of notes taken with a delayed test expectancy resulting in more note-taking activity than an immediate test expectancy. Correlational studies on note-taking have indicated that the probability of recalling an item on a test is much greater if that item was present in the notes than if it is not present. The studies which compared note-taking to no note-taking conditions indicated a positive facilitative effect for note-taking, but the effects of various types of review conditions and the time interval between note-taking and test have not been adequately explored.

Research which has investigated the effects of verbalization in instructional settings have failed to show any clear benefit for methods which involve greater student verbalization. More controlled experimental studies, however, have shown that overt verbalization positively influences associational learning, serial learning, and discrimination learning. Some of the reasons given for these positive effects are that verbalization provides valuable mediators, that it increases arousal, and that it provides important motor and proprioceptive cues to facilitate learning.

Note-taking and verbalization have some features in common and some unique features which can be used to explain their effects on learning. From a theoretical viewpoint, one could argue that both note-taking and verbalization would facilitate learning because these activities induce active associational and coding processes. Engaging in these instrumental activities could also increase arousal, motivation, and selective attention. The external storage feature of note-taking is undoubtedly an important feature for explaining its function in the storage-retrieval process. Current work in mnemonics should have important implications for the mnemonic function which notes can serve. The motor activity and proprioceptive cues which accompany overt verbalization could serve as redundant cues to facilitate learning. In addition a verbalized response provides the additional auditory stimulation which is not available for the unverbalized material. Then, too, auditory storage may be better than visual storage which would also argue for the beneficial effects of verbalization in instructional settings.

In conclusion, there are many psychological principles which can be used as the basis for hypotheses about the effects of verbalization and note-taking, but their effects need to be studied under the many different conditions which define instructional settings.

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Chapter Six

Summary and Overview

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The preceding chapters contain our attempts to organize our own thinking and empirical findings and to integrate our work with that of others. The four chapters represent four major components of our conception of the instructional process: stimulation, orientation, transformation and instrumental activity. In this final chapter I shall first briefly summarize the presentations on those topics, then I shall attempt to provide several threads that tie the chapters together and provide an overview of our conceptualization of the nature of learning in formal educational settings.

Cognitive stimulation was described as a system of intrinsic motivation in which the discrepancy between input and expectation is an essential feature. Once begun, stimulation continues until the discrepancy is resolved either productively or unproductively. The notion of cognitive stimulation as described in Chapter Two suggests guidelines which the instructional decision-maker may consider to maximize learner interest. A first point is that the instructor should highlight the complexity or the novelty of the learning materials. Surface complexity may lead to increased interest in perceptual tasks such as letter recognition. In contrast, potential complexity may foster interest in more academic matters which require the acquisition or transformation of knowledge.

Another principle is that varying such factors as teaching style and mode of presentation, duration of instruction, and the learner's physical position will have the effect of maintaining or heightening attention. When information is withheld due to an instructional communication which is confusing, ambiguous or incomplete, generalized standards are violated with the effect of initiating a general inspection of the instructional topic. However, the instructor should avoid content in which discrepancies are extremely large or not apparent at all to the learner. Once a discrepancy of intermediate size is created the instructor must increase or decrease its magnitude in moderate amounts to prevent habituation. Finally, the form and content of instruction must be shifted more frequently for learners who habituate to discrepancies rapidly or who experience relatively low levels of arousal from them. The dogmatic learner should be cautioned to look at new viewpoints before examining controversial materials and the structurally simple learner must be trained to generate hypotheses and to encode information if he is to benefit from the motivation associated with discovery or inquiry strategies.

General ways in which a teacher is often assumed to exert an orienting influence on students' learning were considered in Chapter Three. The most surprising outcome was the indication that actually telling the student the expected outcome is not a very potent way to facilitate his or her attainment of that outcome. In fact the best way to fully direct the student to overall mastery seems to involve a continual focusing of the student on the lesson by interspersing questions shortly after the question-relevant material has been presented.

Among the less direct ways in which a teacher might influence the goal orientations and learning outcomes of students, the most obvious one - the classroom assignment - has received so little empirical investigation that only prescriptions for additional research were offered. The directive effects of using certain types of tests has not received consistent empirical support, though there is some support for saying that specific versus interrelational nature of questions - whether in essay or objective test form - may lead to predictably different learning outcomes.

The learning mechanisms of our theory were presented in Chapter Four as cognitive activities involving a hierarchy of transformational processes. Transformation is seen as being initiated with the processing of stimulus input through selective attention. The initial outcome is a pattern or percept which is labeled by verbal means for storage.

The first kind of transformation was labeled Type I as a general term for a primary or elementary form of processing. Its unique characteristic is that storage is primarily one-to-one with experience. There is very little, if any, meaningful (e.g., semantic) coding, although learners might impose artificial codes on the material in attempts to facilitate retention. The second kind of transformation (Type II) emphasizes processing by abstraction in which meaningful patterns are extracted from experience through sophisticated coding strategies. The third type of transformations (Type III), called inferential, emphasizes the formation of unique combinations of knowledge into complex patterns of broad generality. Type III transformations allow for the development of new knowledge by permitting logical deduction, derivations, inferences, solutions and the like.

As discussed in Chapter Four, these three levels of transformations provide for delineation of the kind of measures and dependent variables that must be employed with different objectives whether in experimental or instructional settings, as well as indicating the kinds of individual differences possibly relevant to each level.

In Chapter Five instrumental activities were defined as those student activities which occur between task presentation and criterion learning performance and have some bearing on the relationship of the task requirements to the learning outcomes. Note-taking and verbalization were the two instrumental activities studied.

With few exceptions, educators and researchers have looked on note-taking as a facilitative activity in most instructional settings. Correlational studies on note-taking have indicated that the probability of recalling an item on a test is much greater if that item was present in the notes than if it is not present. The studies which compared note-taking to no note-taking conditions indicated a positive facilitative effect for note-taking, but the effects of various types of review conditions and the time interval between note-taking and test have not been adequately explored. The scant research available on the conditions which stimulate or inhibit note-taking have indicated no relationship between the type of test anticipated and the amount of notes taken. The length of time between task presentation and learning performance does seem to be an important determinant of the amount of notes taken with a delayed test expectancy resulting in more note-taking activity than an immediate test expectancy.

Research which has investigated the effects of verbalization in instructional settings have failed to show any clear benefit for methods which involve greater student verbalization. However, more controlled experimental studies have shown that overt verbalization positively influences associational learning, serial learning, and discrimination learning.

Throughout all the chapters the role of the learner has been emphasized. In Chapter Two the learner was viewed as a self-starter, when given subject matter tasks of a novel or complex nature. The learner in Chapter Three was actively involved in determining the probable educational objectives underlying consideration of subject matter. Chapter Four depicts the learner as transforming subject matter, even when the task might be considered a "rote" task. And, of course, as the topic of Chapter Five indicates by its very title, instrumental activities implies an active learner. The "student-centered" orientation of these chapters is a manifestation of cognitive nature of our theory of instruction. We firmly believe that any conception of instruction that is to be valuable in classroom use must place a heavy emphasis upon the learner, who brings to the classroom too much in the way of knowledge, skills, and values to allow us to begin anew each lesson.

A related common theme binding our consideration of topics in the chapters of this volume is the implication that differences in learner's backgrounds and values must be important in designing instructional settings. Though we have not - with very few exceptions - been able to garner empirical support for the validity of such an orientation, we have continued to include potentially relevant learner differences in our discussion of general effects, with the firm belief that the analysis of interactions of learner characteristics with instructional treatments is an essential aspect of any complete study of the instructional treatments.

However, the focus on the learner should not be taken to mean that we consider the teacher's contribution irrelevant. In fact, there is no actual diminution of the teacher's role. Instead, there is a shift in conceptualizing the teacher's impact: We do not see the teacher as conditioning examination responses to subject matter stimuli. We do see the teacher as structuring learning environments by judicious choice of discrepancy-producing situations, by well-planned communication of the educational objectives, and by guidance in the transformational and instrumental activities appropriate for the learning outcomes intended. Thus, in our view, instruction is less a molding of the student than a molding of the environment. Much that occurs in that environment is under student-control, but what is salient in the environment can be considerably determined by the teacher.

APPENDIX

The research which has been supported in full or in part by the Advanced Research Projects Agency (ARPA Order No. 1269) through the Office of Naval Research is listed below. These include technical reports, theses, and research reports which have been published or are currently in press. The contents of the present volume have not been included.

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